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[Continued from SUPPLEMENT No. 1522, page 24390.]

LHASA AND CENTRAL TIBET.—II.*

By G. Ts. Tsybikoff.

I WILL now describe the more or less prominent cities and monasteries visited in Central Tibet. Chief of all, of course, is the capital, Lhasa, sometimes called "Kadan" in literature, but both names have almost the same meaning — "the land of gods." Its origin dates from the time of Khan Srongzang-Gambo, who lived in the seventh century A.D. It is said that this khan had among his wives one Nepalese and one Chinese queen, each of whom brought along a statue of the Buddha Sakyamuni, to whose worship temples were erected in Lhasa, and he settled on Mount Marbo-ri, where the palace of the Dalai Lama now stands. Lhasa is situated on a broad plain, bordered on one side by the river U-chu and on the other by high hills. If we disregard the Potala, or palace of the Dalai Lama, the city is nearly round, with a diameter of about a mile. But the numerous orchards in the southern and western parts, the proximity of the Potala with the adjacent medical college, the court of Datsaghutuktu, and the summer residence of the Dalai Lama led to the belief that it was about twenty-five miles in circumference. As a matter of fact, the circular road along which the pious make their marches on foot or in prostrate bows is but very few miles long. When these bows are faithfully performed the circle is completed in two days, making about three thousand bows a day.

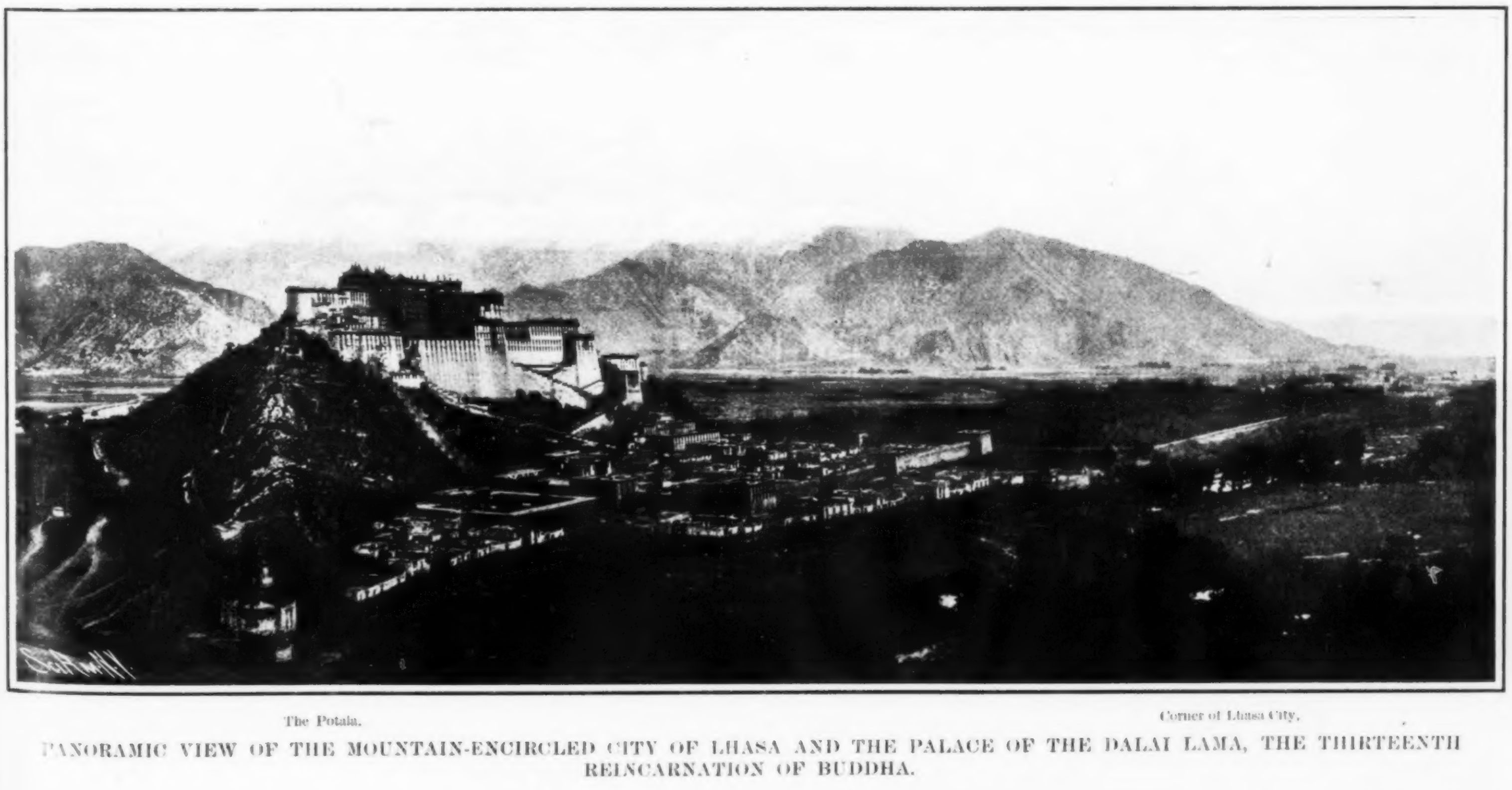
The orchards and trees in the outskirts of the city are admired by the natives, and give the place a very beautiful appearance, especially in the spring and summer, when the gilt roofs of the two principal temples glisten in the sun and the white walls of the many-storied buildings shine among the green tops of the trees. But the delight of the distant view at once vanishes upon entering the city with its crooked and dirty streets.

A temple in which there is a large statue of Buddha marks the center of the city. The building is one hundred and forty feet square, three stories high, with four gilt roofs of Chinese design. The entrance gate faces the north. Each floor of the temple, with its blind external walls, is divided into numerous artificially lighted rooms, where-

* Translated from the Izvestia of the Imperial Russian Geographical Society, St. Petersburg, vol. xxxix, 1903, part iii, pp. 187-218, for the Smithsonian Institution.

A VIEW OF LHASA FROM A NEIGHBORING HILL.

The building crowning the peak about the center of the picture is the monastery of Sera, which is famous in Tibet for its ascetics. The civilian population of Lhasa scarcely exceeds 10,000 persons, about two-thirds of them women, although the number may seem greater on account of the proximity of two large monasteries, the many transient visitors, and the gatherings of worshipers from lamaite countries.



The Potala.

Corner of Lhasa City.

PANORAMIC VIEW OF THE MOUNTAIN-ENCIRCLED CITY OF LHASA AND THE PALACE OF THE DALAI LAMA, THE THIRTEENTH REINCARNATION OF BUDDHA.

in stand various statues of Buddha. In the middle room on the east side stands the principal object of worship, Buddha Sakyamuni, under a sumptuous canopy. This bronze statue differs from the usual representations of the Indian sage in its head and chest ornaments of wrought gold set with precious stones, with a predominance of turquoise prepared and placed upon it by the famous founder of yellow-hat teachings, Tsongkapa. The face of the statue ever since the days of that same Tsongkapa has been kept painted by devout worshipers with gold powder dissolved in liquid glue. Upon long tables before the god, melted butter, offered by the worshipers, ever burns in golden lamps. Two other statues in the temple command almost equal respect—the eleven-faced bodisattva Avalokiteshvara, of which the Dalai Lamas are regarded as incarnations, and the statue Pal-Lhamo, the protectress of women. . . . Under the latter statue barley wine is being incessantly sprinkled and grains are freely scattered. Abundance of food and snug hiding places in the folds of the clothing of the statue have attracted numerous mice, that are here considered holy. . . .

Besides the principal court of the temple there are two additional courts, in which the gatherings of the clergy of the neighboring monasteries are held.

Another small statue of Buddha stands in a temple in the northern part of the city and is called "Jovoramoche," but both temple and statue are inferior in proportions and ornaments to the main temple, and there is a noticeable difference in the reverence of the worshipers.

Within the city limits of Lhasa there are four courts or quarters of eminent Hutuktu incarnates, who were

PALACE OF THE OLD KING OF TIBET, AT LHASA.

The clothing of a Tibetan is of special design, made from native cloth in various colors. The poor classes wear white, the cheapest color; the richer people wear red and dark red, the soldiers dark blue, and yellow is used by higher dignitaries and princes. Women prefer the dark red cloth. Of course other colors are also met with. In proportion to their means, Tibetans dress rather elegantly. Their jewelry is of gold, silver, corals, diamonds, rubies, pearls, turquoise, and other stones.

once Tibetan khans. They are the best buildings in the city, and as each has a certain number of pupils of the Lamas they are really small monasteries. Then, each of the eminent incarnates has his own inherited house. All other buildings belong either to the central government, or to the various communities of the neighboring monasteries. Buildings owned by private individuals are few and are mainly in the outskirts of the city.

All these buildings are under the control of the palace of the Dalai Lama, Potala, about two-thirds of a mile west of the city, and built upon a rocky height. The foundation of the palace, tradition says, was laid by the above-named Srongzang Khan during the seventh century, but it was remodeled, with the addition of the main central portion, called "Pobrang-marpo" (the red palace), during the life, and even after the death, of the fifth eminent Dalai Lama. It is evident that the palace and additions were planned to serve as a means of defense, and from this point of view Potala looms up as one of the old castles, of which many ruins abound in Tibet, and in the sad fate of which Potala played the pre-eminent rôle by subjecting them to itself.

The palace is about 1,400 feet long and about 70 feet high in front. The front and two sides are surrounded by a wall, the rear portion extending into the hill. In the construction of this palace the Tibetans displayed their highest architectural skill. Here are found the most precious treasures of Tibet, including the golden sepulcher of the fifth Dalai Lama, which is about 28 feet high. The treasures and apartments of the Dalai Lama are in the central portion of the temple palace, which is painted a tawny color and known as the "red palace"—Pobrang-marpo. The remainder of the building serves as quarters for various attendants or followers of the Dalai Lama, including a community of 500 monks, the so-called "Namgyaltsan," whose duty it is to pray for the welfare and long life of the Dalai Lama.

Near the hill are the mint, the house for the Dalai Lama's subjects, the prison, and other structures. Upon the continuation of this hill stands the convent Mänbo-datsang, where sixty monks devote themselves to the study of medicine at the expense of the Dalai Lama. A little farther north is the idol temple of the Chinese Buddhists, and at the northwest foot of the hill is the palace of the fifth eminent hutuktu Kunduling, and about two-thirds of a mile west of the latter is the summer palace of the Dalai Lama.

There are in Lhasa two temples where mysticism is taught, with an attendance of 1,200 men.

The civilian population of Lhasa scarcely exceeds 10,000 persons, about two-thirds of them women, although the number may seem greater on account of the proximity of two large monasteries, the many transient visitors, and the gatherings of worshipers from lamaite countries. As the political and religious center of Tibet, its sanctuaries an attraction for numerous worshipers, Lhasa becomes an important business place, as well as the connecting link in the commerce between India and northern Tibet and China with the East.

The market place is located around the central or temple section, where all the ground floors of buildings and open spaces in the streets are occupied by stores and small exhibits of merchandise. Women are pre-eminently the sales people, although in the stores of the Kashmiris and Nepalese men do the selling.

About the town stand the principal monasteries of Tibet, Sera, Brebung, and Galdan, known under the common name Serbre yesum. Brebung, the largest, is about seven miles northwest of Lhasa; next comes Sera, about two miles north of the city, and last, Galdan, about twenty miles distant to the left of the river U-chu, on the incline of the steep mountain Brog-ri. They belong to one ruling sect of Tsongkapa and were organized during his lifetime, at the beginning of the fifteenth century. The Dalai Lama is regarded as the head of them all. There are 15,000 to 16,000 monks in all, of which 8,000 to 8,500 are in Brebung, 5,000 in Sera, and 2,000 to 2,500 in Galdan. In the Galdan monastery there is a vice-Tsongkapa under the name, the "Galdan golden throne," a position established immediately after the death of the organizer, at the suggestion of his pupils and disciples. In olden times that office was filled by the choice of the Galdan monks, but on account of the confusion that followed elections the present method of installation was instituted, and the position is now filled in six-year terms by two Lamas, or, more correctly, wandering ecclesiastics, "Chzhuds," in the order of their service in the higher positions of their temple. The present incumbent is the eighty-fifth superior since Tsongkapa, or the eighty-sixth superior of Galdan, counting the reformer as the first.

Each of the monasteries has its laws and its own land, and they are thus independent of one another. The Brebung monastery is the most influential, because of its wealth and numbers, which are both the cause and the effect. Much of this superiority is also due to the fact that Brebung monks were elevated to Dalai Lamas, to whose lot it soon fell to be at the head of the spiritual and civil government of Central Tibet. The lamaiste monasteries are now not so much places of refuge for ascetics, as schools for the clergy, beginning with the alphabet and reaching to the highest theological knowledge.

It is true that the public school begins the instruction in religion, but the elementaries as well as the domestic occupations of adults are taught by private teachers chosen by the pupil. Nevertheless, every one, be he a boy five or six years old or a mature and even old person, is regarded as a member of the congregation and receives maintenance by becoming subject to the monastery laws. The principal subject taught is theological philosophy, which consists of five sections of dogma, compiled by Indian pundits and translated into Tibetan. After the Tsongkapa reform, commentaries were made by various learned men upon those sections, which, according to the Lamas, do not differ in substance, all the commentaries adhering to the general idea of the teachings of the famous reformer. In the monasteries mentioned religion is taught from commentaries of six scholars in seven editions, each of which has a separate faculty. Three of these are Brebung and two each in Sera and Galdan.

Besides these religious faculties the first two monasteries have a faculty called "Agpa," to perform the mystic rites and to pray for the welfare of the monastery. The clergy is very unevenly divided in the various faculties. In Brebung, for instance, there are 5,000 men in one faculty and only 600 in the other.

It must be admitted that the monastic communities seem more concerned in securing "daily bread" than in the education of their members. Honors and degrees are conferred only upon those who endow the community in some practical manner. High positions, too, are encumbered with an obligation to distribute gifts among the members of the community. The principal source of endowments comes from the incarnates; that is, the incarnates of the soul of some predecessor. Whosesoever soul he may incarnate, he is recognized in the community as such only after he has distributed a certain amount of money and food. On the other hand, howsoever learned a monk may be, he receives the degree only after he has made endowments. Consequently charity and scholarship are measured by the amount of gifts to the monastery communities.

Each monastery has some special characteristic. Thus Brebung is famous for its prophets, Sera for its cells for the ascetics, and Galdan for various old curios.

The cult of the prophets or oracles is in its turn based upon the cult of the so-called "Choichong," or the guardians of learning. Judging by historical tradition it may be presumed that Buddhism, introduced into Tibet in the seventh century A. D., could not be rapidly developed because of difficulty in conquering the native gravitation toward their former deities, to which the people were accustomed and which were dear to them because they were their own creation. Besides, the sorcerers or priests were no doubt defenders of the old cult. On the other hand, however, Buddhism was protected by the rulers of Tibet and was bound to spread, and in the hard struggle popular superstition was granted some concessions. This compromise between Buddhism and sorcery was made, we

are told, by a preacher of the ninth century, Padma-Sambava. He compelled the former local spirits to swear that henceforth they would defend Buddhist learning only, for which they were promised honors, rendered in the form of sacrifice of wine, barley seeds, etc. The highest of these spirits, which were imported from India, are called "Idma," while those of lower rank are called simply "Choichong," or "Choisrung." The Choichong speak with the lips of the prophets whom they inspire. Only Choichong of lower degrees thus descend to prophets. As protectors and defenders of the faith the people imagine them to be horrible monsters in warriors' outfit. On this account the prophet, before the descent of "Choichong" upon him, dons a helmet and arms himself with spear, sword, or bows and arrows. The sense of the descent is contained in the fact that the spirit guardian of learning becomes incarnated in the chosen prophet for the sake of the living beings. Of such spirit guardians there are many, and the prophets are correspondingly numerous. The superior among them is the one confirmed by the Chinese government—the Prophet Naichung-Choichong, whose gold-crowned temple and church suite is in the shady garden southeast of the monastery of Brebung. He is appealed to for prophecies, not only by ordinary mortals, but by all the higher clergy, including the Dalai Lama. Their mutual relation is as follows: Lama is "the abode of learning," and Choichong, its "guardian," having sworn to defend the religion vigilantly, will be honored of all for it. The Lama, therefore, honors—that is, brings sacrifices to—the Choichong, and the latter forestalls all that threatens the religion and the Lama, its representative. They constitute a check on each other and are allies at the same time. In this rôle of defenders of the faith the Choichong—or, more correctly, their prophets—wield a powerful influence over all classes. Their powèr is so great that even the Dalai Lama and the highest Hutuktu must reckon with them; they endeavor to incline all toward themselves.

The "ritods," who are particularly numerous at Sera, are ascetic monks, who have retired from the world and buried themselves in meditation, which is regarded as one of the six means of attaining holiness—its origin based on Gautama's abdication of kingly luxuries in search of truth. The later ascetics choose obscure nooks in dense forests or dark caves in the rocks as places for meditation. More recently they have concerned themselves not only about their own attainment of holiness, but about the good of others, and their peaceful existence became distracted by the care of enlightening fellow-men. The silence of the cell for solitary meditations was broken by the cries of those hungry for knowledge, and to the lot of the ascetics fell the new care of their spiritual and material satisfaction. Then the idea of worldly vanity and comfortable quarters enticed the ascetics, and the cells were converted into comfortable dwellings, with quarters for pupils. The ascetic was thus transformed into the full master and ruler of his servants. Later on, with the appearance of the incarnates, the ritods become the inheritable property of the incarnates of the organizer, and several are transformed into separate monasteries.

However, the people still revere the ritods, and the tombstones of some of them are coveted last resting places for the dead; upon them the corpses are cut up for the distribution of the flesh and bones among the griffin-vultures.

The relic curios, in which Galdan is rich, show us to what an extent the famous Tsongkapa took possession of the minds of his followers. His successor after his death sought memorials of the existence of the dear teacher, not content with his works. He did not believe that a teacher could pass away leaving no footprints, and search was made for these everywhere about the monastery he established—where he passed his last years. His searches did not end in failure, and in various groves and among the rocks he saw traces of the wonder of the teacher, and explained them by one or another incident in his biography, and, conversely, with his biography explained those traces. Frequently meditating about his idolized teacher, he drew and chiseled his image upon rocks, and the images of the Buddhas, his protectors. In course of time all these signs and statues made by the closest of pupils of Tsongkapa under the known influence of superstition began to be taken for wonderful relics and each worshiper began to venerate them.

It is characteristic that such relics are being discovered up to the present time. Thus the present Dalai Lama obtained from a rock a treasure, consisting of a hat and other articles, ascribed to Tsongkapa. He deposited the treasure in a special chest and placed it for safekeeping at the sarcophagus of Tsongkapa and on its place erected a monument.

(To be continued.)

BUDDHIST TEMPLE IN THE CENTER OF LHASA.

MEXICO TO EXPLORE AN ANCIENT OTOMITE CITY.

The government of Mexico is about to send an expedition of archæologists to explore some ancient ruins of what is believed to be the lost city of Teayo, which was, more than 300 years ago, the capital of the Otomite kingdom in that country. According to the San Francisco Call the ruins were found by a party of Americans who were investigating a report of the existence of coal deposits. When they reached the Otomite territory, they found an Otomite Indian whom they employed as guide. They found no coal where it was said to exist, and they resolved to continue their journey into the wilds for the purpose of seeing what they might discover. Guided by the Otomite Indian they traveled over mountains and through dense jungles of tropical forests for fourteen days. They came upon a number of small settlements of Otomite Indians, and but for the fact that their guide interceded in their behalf they would have met with a hostile demonstration at the hands of these natives. They were the first white men to penetrate the region, and their appearance was a sensational event to the Indians, who have never submitted to or acknowledged the authority of the Mexican government over them. The Otomites proudly boast that they are still unconquered.

On the fourteenth day the Americans came within sight of the city of Teayo. The sacrificial tower, which rises to a height of 65 feet, attracted their attention when some distance away from the city. The Otomite guide went forward and obtained permission from the inhabitants of the ruined city for the Americans to enter. They spent several days viewing the ruins of the ancient capital, which in the days of its glory had a population of not less than 500,000 people. They obtained a large number of good photographs of the different ruins and views of the city.

These photographs include hieroglyphics which exist in the city. It is believed that when these hieroglyphics are deciphered they will show that a discovery of great archæological value has been made. In an interview one of the members of the party of explorers gave the following description of the ruined city:

"The sacrificial tower, which now rises 65 feet above ground, formerly had an altitude of more than 100 feet. It has been reduced in height by the erosion of the centuries. There are great quantities of stones detached from it scattered over the ground at its base. When the great age of this pyramid or tower is considered, it is the best preserved monument of Mexican antiquity known to exist. At the base of the tower, the north and south sides are 65 feet wide and the east and west sides are 75 feet wide. A stone stairway 30 feet wide runs up the tower on the east side. It is estimated that at least 40,000 tons of material were used in constructing this monument.

"Another interesting feature of the ancient city is the great central underground chamber. The Otomites constructed underground thoroughfares through all parts of the city, and many of these dark and gloomy passages and chambers are still in a good state of preservation. This system of underground thoroughfares radiated from the sacrificial tower. Many of them are walled with stone, upon which the beautiful work of the sculptor is still to be seen.

"I saw underground chambers which were filled with skeletons of men said to have been the victims of religious rites. The labyrinth of underground passages, chambers, and vaults will probably reveal a great store of information bearing on the past history of the Otomites when properly explored and investigated. One of these subterranean passages runs from the center of the city to a surface opening in the face of a cliff, seven miles distant. It is said that no one has entered this mysterious passage for many decades. It was used to provide the imperial family a means of exit from the capital in time of emergency.

"The ancient Otomites excelled the Aztecs in sculptural art, as is shown by the splendid expressions of the human face on stone wrought by the Otomites as compared with that of the Aztecs. The tomb of Tlachimoc, the last of the emperors of the Otomites, is one of the things of interest which we saw at Teayo. The tomb has a raised cover, upon which two sphinx-like figures stand like guards over the pagan ruler. A cross of mahogany, erected in recent years, surmounts the cover.

"At each corner of the paved area over the tomb stands a sculptured stone taken from some ancient lodging place to do honor to the memory of the dead Emperor. One of these stones is eight feet high and is covered with allegorical figures, inscriptions, and hieroglyphics; another of the stones represents a prince, a third a wise man, and the fourth a woman, who is minus her head.

"The Otomites sacrificed the lives of their victims by casting their bodies from the top of the tower through the hole which formed the center of the structure from top to bottom. The bodies fell into the subterranean passage under the tower. Otomite Indians are of light complexion. In the days of their power they were well advanced in civilization."—The American Architect.

Copal Varnish for Oil Cloth.—Mix 750 kilos of thick oil (pure linseed oil boiled for 24 hours with 27 kilos of manganous borate to 300 deg. C.) and 225 kilos of melted kauri copal, according to the desired consistency, with the necessary quantity of oil of turpentine or benzine.

The copal is melted alone, and added to the hot oil, with which it combines.

Turpentine oil or benzine dissolves the whole, and must not be added too hot. When it is entered, the fire under the kettle must be withdrawn and all possible care exercised.—Der Chemisch-Technische Fabrikant.

THE TANTALUM LAMP.*

By Dr. W. Von Bolton and Dr. O. Feuerlein.

PART I.—BY DR. W. VON BOLTON.

While the carbon filament incandescent lamp remained for nearly two decades the sole representative of glow-lamp manufacture, progress was being quietly made in this art. The firm of Messrs. Siemens & Halske has for many years been working at a solution of the problem of an economical incandescent lamp, and arrived, some time ago, at the fundamental principle that the visible part of the radiation of an incandescent body increases progressively with its temperature. This warrants the postulate that the most economical lamp will be that whose incandescent material will withstand the highest temperature.

Messrs. Siemens & Halske had arrived at this conclusion and charged me several years ago with the task of discovering a material which should have a melting point considerably above the temperature at which incandescent lighting becomes highly economical, so that filaments made of such a material would not melt or disintegrate at that temperature. While our laboratory work, founded upon this idea, was going on, the first two advances in incandescent lighting were made public, one being the "Nernst" and the other the "osmium" lamp.

There are certain metals the melting points of which are known to be considerably above 2,000 deg. C., and the task resolved itself into finding one which, while fulfilling the above requirement, could be easily worked to form a filament, and not be very rare or difficult to procure. It was early observed that brown vanadium pentoxide, which, according to Berzelius, does not conduct electricity, is, as a matter of fact, a conductor even when cold. This observation induced me to try whether vanadic acid could not be electrolytically decomposed. In this I succeeded, but the melting point of the vanadium obtained proved too low for the purpose in view. Since the metals niobium and tantalum are members of the vanadium group, niobium having an atomic weight double that of vanadium while the atomic weight of tantalum is double that of niobium, it was thought that one or both of these metals might prove to have the desired qualities. On experimenting with niobium on the lines adopted for vanadium, it appeared that this metal has a considerably higher melting point than that of vanadium, but not, however, sufficiently high; moreover, some of the niobium filaments which I made had a very strong tendency to break up when heated by the electric current.

Tantalum was tried next. I reduced potassium tantalo-fluoride in the manner prescribed by Berzelius and Rose and found that the finely divided tantalum so produced became fairly coherent on rolling, so that by this treatment metallic strips of it could be made. It was also attempted to work tantalum oxide into the shape of a filament by mixing it with paraffin and to reduce it directly into the form of a metallic thread. In these experiments there was observed for the first time a minute globule of molten tantalum, and this globule was of sufficient toughness to permit hammering and drawing into wire. Following out this observation, tantalum powder was melted in a vacuum, and then it was found that the highly-heated metal parted with the gases it contained. In this manner I produced my first filaments of pure metallic tantalum, which were, however, very small. When these had been used in lamps with promise of good results, an attempt was made to devise a definite process of purification. The

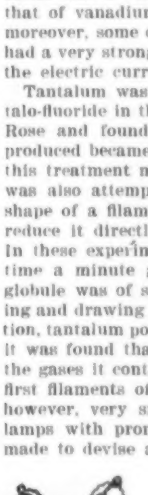


Fig. 1.—Lamp with Corrugated Filament.

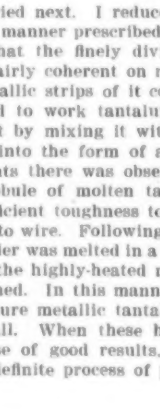


Fig. 2.—Early Type of Tantalum Lamp.

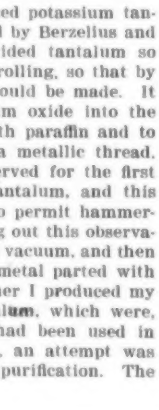


Fig. 3.—Tantalum Lamp with Filaments Fixed Obliquely.

potassium tantalo-fluoride was reduced to metallic powder; this powder contains a small proportion of oxide and of hydrogen which is absorbed during the reduction. When the powder was melted in a vacuum the oxide and absorbed gas disappeared, and a reguline metal remained; on carefully remelting this it became so pure that no appreciable impurities could be detected in it.

* Translation of a paper read before the Elektrotechnischer Verein of Berlin on January 17.

The chemical properties of this pure tantalum are very remarkable, and some of them are of such a nature as to lead me to suppose that nobody other than myself has ever had metallic tantalum in his hands. When cold, the material strongly resists chemical reagents; it is not attacked by boiling hydrochloric acid, aqua regia, nitric acid, or sulphuric acid, and it is also indifferent to alkaline solutions; it is attacked solely by

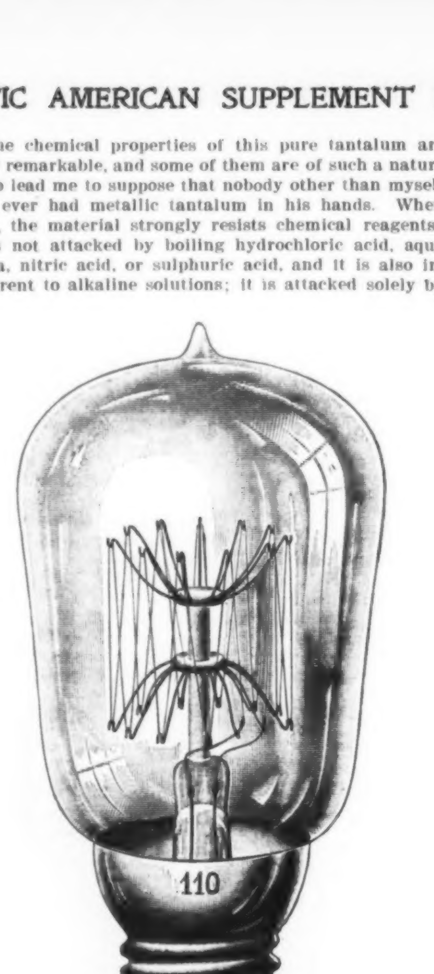


Fig. 4.—Complete Lamp. Full Size.

hydrofluoric acid. Following the behavior of steel, when heated in the air, it assumes a yellow tint at about 400 deg. C., and the tint changes to dark blue when the tantalum is exposed for some time to 500 deg. C., or for a shorter time to 600 deg. C. Thin wires of the substance burn with low intensity and without any noticeable flame when ignited. It absorbs hydrogen as well as nitrogen with great avidity, even at a low red heat, and forms with them combinations of a metallic appearance, but rather brittle. It combines with carbon very easily, forming several carbides which, as far as they are at present known, are all of metallic appearance, but also very hard and brittle. The product which Moissan thought to be tantalum was clearly a carbide of this nature or an alloy of a carbide with pure tantalum, for Moissan himself stated that his metal still contained one-half per cent of carbon. Considering the high atomic weight of tantalum (183) it is obvious that a very small quantity of carbon suffices to carburize a relatively large quantity of tantalum. This view of the constitution of Moissan's product is confirmed by the properties he ascribed to the metal—namely, specific gravity 12.8, great hardness and brittleness. These are not properties of pure tantalum. When in the form of powder, still containing, as previously stated, oxide and hydrogen, the specific gravity of my material is about 14; when purified by fusion and drawn into wire it has a specific gravity of 16.8. It is somewhat darker than platinum, and has a hardness about equal to that of mild steel, but shows greater tensile strength than steel does. It is malleable, although the effect of hammering is relatively small, so that the operation must be rather long and severe to beat the metal into a sheet. It can be rolled, as well as drawn, into very fine wire. Its tensile strength as a wire is remarkably high, and amounts to 95 kilogrammes per square millimeter while the corresponding figure for good steel is 70 kilogrammes to 80 kilogrammes, according to Kohlrausch.

The electrical resistance of the material at indoor temperature is 0.165 ohm for a length of 1 meter and a section of 1 square millimeter (specific conductivity as compared with mercury 6.06). The temperature coefficient is positive, and has a value of 0.30 between 0 deg. C. and 100 deg. C. At the temperature assumed by the incandescent filament in the lamp at 1.5 watts per candle-power, the resistance rises to 0.830 ohm for a length of 1 meter and a section of 1 square millimeter. The coefficient of linear thermal expansion between 0 deg. C. and 60 deg. C. is 0.0000079, according to experiments made by the Imperial Normal-Aichungs commission. Fusion is preceded by a gradual softening, which appears to extend over a range of temperature of several hundred degrees. The specific heat is 0.0365, so that the atomic heat is 6.64, which is in accord with the law established by Dulong and Petit.

PART II.—BY DR. O. FEUERLEIN.

The results of the work carried out in our chemical laboratory, as described by Dr. Von Bolton in the first part of this paper, were, of course, of the utmost interest to our incandescent lamp manufacturing department. As soon as Dr. Von Bolton's experiments showed that the originally brittle tantalum could be made ductile enough to draw into wire by the usual methods, and that this wire could be bent and coiled like a thin steel wire, it became possible to test it thoroughly as to its usefulness for incandescent lamps. The first trials with wires of about 0.3 millimeter diameter gave most promising results. They confirmed the fact that tantalum has a very high melting point, and that it is but slightly subject to disintegration in a vacuum, even when subjected to a heavy current.

The first tantalum lamp that proved moderately satisfactory in that it admitted of an exact measurement of the electric and photometric conditions and stood a burning test for some time, was completed just over two years ago, viz., on December 28, 1902. This lamp had a loop-shaped filament made of the first tantalum wire ever drawn. The diameter of the wire was 0.28 millimeter, its effective lighting length 54 millimeters, and its electrical resistance when cold 0.29 ohm. This corresponds to a specific resistance (1 meter length, 1 square millimeter section) of 0.331. The photometric measurements made at efficiencies of 2, 1½, and 1 watt per Hefner candle-power showed potential differences of 4.9, 4.95 and 5.9 volts, currents of 5, 5.46 and 6.2 amperes, and illuminating values of 11, 18 and 37 Hefner candle-power respectively. On being burnt at 1 watt per candle-power the lamp had a life of 20 hours, during which it blackened considerably.

As the chemical and mechanical manufacturing processes developed and the material became purer and the wires more uniform, the results obtained also improved. The lamps lasted longer and blackened less; at the same time the specific resistance decreased until it had dropped to the present figure of 0.165 for the pure metal. It is clear that the material used for the first lamps still contained a considerable quantity of impurities, probably niobium and carbides, which caused the great disintegration and the nearly double specific resistance. During these first trials we looked very carefully into the question as to what dimensions the filament of a tantalum lamp ought to have for ordinary voltages and illuminating values. From the dimensions of the filament used in the first lamp we calculated that, with this rather impure material, we should require a filament about 520 millimeters long and 0.06 millimeter diameter for a lamp for 110 volts, 32 Hefner candle-power and 1.5 watts per candle-power. These unusual figures increased when the specific resistance of the material had diminished to the present value of 0.165, at which for a 32 Hefner candle-power lamp, a filament of about 700 millimeters in length by 0.055 millimeters in diameter was required; for a 25 Hefner candle-power lamp, a filament of about 650 millimeters by 0.05 millimeter diameter was required. Thus, in order to construct a practical and useful lamp for standard voltages and illuminating values, we had to solve the problem of drawing the tantalum wire in sufficient length down to a diameter of 0.05 millimeter to 0.06 millimeter; this we succeeded in doing after long and laborious trials.

In July, 1903, we possessed the first tantalum lamp with a filament of about 0.05 millimeter diameter. It had a loop-shaped filament 54 millimeters long and it took 0.58 ampere at 9 volts and gave 3.5 Hefner candle-power at 1.5 watts per candle-power. On the basis of these figures a lamp having the same quality and diameter of wire and working at the same efficiency on a 110-volt circuit would have a filament 650 millimeters long and would give 43 Hefner candle-power. The experiments thus far had proved that the task of producing lamps for 110 volts and a maximum of 25-32 Hefner candle-power was not an easy one in several respects. We had to solve the problem of suitably and reliably fixing a filament rather more than 2 feet long within a glass globe which should not exceed to any great extent the dimensions of the usual incandescent lamps. The first and most obvious attempt was made,

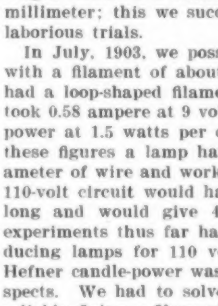


Fig. 5.—Tantalum Filament, Before and After 1,000 Hours' Use

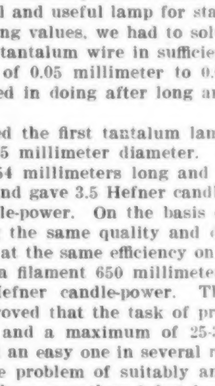


Fig. 6.—Filament Frame of a New Lamp.

of course, by adhering to the loop shape and accommodating the required length of wire by connecting several such bows in series within the lamp. However, lamps made according to this plan with two to four tantalum loops gave results which were anything but satisfactory.

It appeared that, like all other metallic filaments which have hitherto been used for incandescent lamps, tantalum wire softens sensibly at the temperature attained when worked at 1.5 watts per candle-power. To use loop-shaped or spiral filaments similar to the car-

bon filaments of the common incandescent lamps, was, therefore, out of the question. There was no difficulty in suspending the loops, but in that case the lamps would have to be used exclusively in a vertical position, a limitation which we wished to avoid in all circumstances. Besides, such a construction would necessitate staying the loops firmly to prevent them from becoming entangled with each other during transport of the lamps. Nor did lamps made with loops of corrugated wire (Fig. 1), or of plain or corrugated metal ribbon give satisfaction; for although the loops were certainly shortened in this way, there were other drawbacks which caused us to abandon this construction. It soon became apparent that the one road to success lay in the direction of dividing the filament into a number of short straight lengths supported at their ends by insulated holders. In this manner we succeeded at last, in September, 1903, in producing the first really serviceable lamps for about 110 volts. This lamp is illustrated in Fig. 2, and it will be seen that it contains two glass disks cast to a central wire holder; each disk carries laterally twelve arms having small hooks at their ends and insulated from each other. Through these twenty-four hooks the thin tantalum wire is drawn up and down between the two disks. This is believed to be the first metallic incandescent lamp for nearly 110 volts which, like the common carbon glow lamp, can burn in any position whatsoever. This lamp supplied about 30 Hefner candle-power on a 94-volt circuit at 1.5 watts per candle-power. It lasted for 260 hours and lost during that time 9.5 per cent of its illuminating power.

After this first practical success we redoubled our efforts to improve the lamp further. As far back as about the middle of October, 1903, we succeeded in making the first 200-volt tantalum lamp, which was of a design similar to the lamp just described, but with eighteen arms on each disk and with a greater distance between the two disks. I may add at once that it is of interest only as a curiosity, for it has served no practical purpose. The length of its filament was 1,350 millimeters and the illuminating value about 60 Hefner candle-power. In the course of further development the form of the frame of wire filament for the 110-volt lamp went through different stages, the principle of subdivision being always followed. Among other constructions we tried some in which, instead of one long filament, a number of short pieces of wire were fixed on a supporting frame; these pieces, connected in series, made up the total length required. Fig. 3 represents a lamp thus constructed, the wire being fixed obliquely in sixteen straight pieces between two insulated supporting stars. Such lamps offer the advantage that short pieces of filament can be used in the manufacture. But they are only reliable if the wires used in the same lamp are absolutely uniform in diameter and quality. In the end we arrived at the shape represented in Fig. 4, which is for 110 volts, 25 candle-power and 1.5 watts per Hefner candle-power. In this form, differing from most of the previous constructions, the central support consists of a short glass rod carrying two disks, into which the arms, bent upward and downward in the shape of an umbrella, are cast. The upper star has eleven, the lower twelve arms, each upper arm being in a vertical plane midway between the vertical planes in which two adjacent lower arms lie. Between these eleven and twelve arms, which are bent into hooks at their ends, the entire length of the filament is drawn in a zigzag fashion. Its extremities, held by two of the lower arms, are connected with the foot of the lamp by means of platinum strips.

The standard type for 110 volts 25 Hefner candle-power and 1.5 watts per candle-power has a filament 650 millimeters long and 0.05 millimeter in diameter. The weight of this filament is 0.022 gramme, so that about 45,000 lamps contain together 1 kilogramme of tantalum. The shape of the glass globe is adapted to the frame described above. Care has been taken to make it of a size not exceeding the usual maximum dimensions of common incandescent lamps of the same candle-power (25 Hefner candle-power 110 volts). This shape offers a number of noticeable advantages. In the first instance it is very stable and will stand strong shocks without damage to the lamp. A considerable number of such lamps sent across the sea to test their ability to withstand the hardships of transport came back unhurt, although they had been packed just like common glow-lamps, and no special care in any respect had been taken in their handling. The lamp burns, of course, in any position, and can therefore be held in any kind of fitting. The light is rather white and agreeable, and its effect is particularly uniform if the lamp is provided with a ground-glass globe.

We shall now proceed to describe the electric and photometric properties of the lamp and its behavior in actual use. Numerous trials for lengthy periods of time at 1 to 3 watts per candle-power have proved the vast superiority of the tantalum lamp over the carbon filament lamp under equal electric and photometric conditions. Expressing this fact in figures, we can state that the tantalum lamp consumes about 50 per cent less current at the same voltage, with the same intensity of light and the same useful life; or that, at the same economy, its life is several times that of the carbon type. Moreover, at an initial efficiency of 1.5 volts per Hefner candle-power the tantalum lamp has an average life quite sufficient for all practical requirements, so that this rating has been standardized for the 110-volt lamp. Trials have also proved that the lamps have a life of several hundred hours at 1 watt per Hefner candle-power, but in that case they were very sensitive to variations of pressure and often showed an early decrease of illuminating power. The useful life of the tantalum lamp—i.e., the time within which it loses 20 per cent of its initial illuminating power—averages between 400 and 600 hours at 1.5 watts per Hefner candle-power. Some specimens have proved to have a useful life of as much as 1,200 hours. The absolute life, in general, amounts to 800 to 1,000 hours under normal working conditions. Further, we have to remark that the tantalum lamp blackens but little unless it has been strongly overheated during work in consequence of partial short-circuiting of the filament.

It is very interesting to observe the behavior of the tantalum lamp during the whole course of its life. The first fact worthy of note is that, like some carbon lamps, the illuminating value increases at the beginning, generally after a few hours, by 15 to 20 per cent. In the same way the consumption of current rises by about 3 to 6 per cent, while the consumption of energy drops to 1.3 to 1.4 watts per candle-power. After that, the illuminating value gradually decreases, while a corresponding increase of the consumption of energy occurs. The average behavior of the 25 candle-power lamp at 110 volts with reference to its various periods of life is shown in the following table:

Life in hours.	Intensity of light in Hefner c. p.	Consumption of current in amperes.	Watts per Hefner c. p.
0	25-27	0.36-0.38	1.5-1.7
5	28-31	0.37-0.39	1.3-1.5
150	25-27	0.36-0.38	1.5-1.6
300	22-24	0.36-0.38	1.6-1.7
500	20-22	0.36-0.38	1.9-2.0
1,000	18-20	0.35-0.37	2.1-2.2

The initial increase of illuminating value and of current consumed is doubtless caused by a change in the structure of the tantalum wire, this change being accompanied by a reduction of resistance and, consequently, of the phenomena resulting therefrom. We may say at once that after a certain amount of use the filament presents a radical change in appearance when viewed with the naked eye. While the fresh filament has a perfectly smooth and cylindrical surface, it acquires a peculiarly glistening aspect as it grows old, so that a lamp having served for some time can be readily

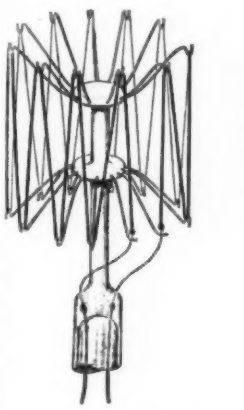


Fig. 7.—Appearance of Filament After Having Been in Use.

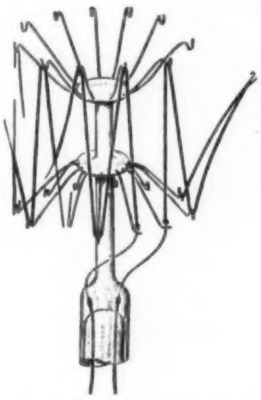


Fig. 8.—Filament Frame, Showing Broken Filament

distinguished from a new lamp. When looked at under the microscope, the filament that has burned for a length of time shows a clear tendency toward contraction and formation of drops or beads. Fig. 5 is an illustration of a piece of filament in its fresh state and of the same piece after 1,000 hours of service, the specimen in each case being magnified 100 times. This gradual shortening of the filament can also be observed in the lamps themselves, and offers a further indication of the age of a lamp.

Fig. 6 represents the filament frame of a new lamp. It will be noticed that the tantalum wire is led up and down and hangs loose on the supporting frame in easy wide arches, without sharp bends. But after being used for some time the aspect of the lamp is quite different. As shown in Fig. 7, the wire has contracted, the wide arches have disappeared and sharp-pointed angles have taken their places.

The behavior of these lamps is most peculiar when the filament has burned through. While with all other incandescent lamps the burning through of the filament is tantamount to the economical death of the lamp, it may happen with tantalum lamps that they burn through several times without being rendered useless; on the contrary, each burning through is followed by an increase, often considerable, of the illuminating power. This peculiar result is due to the fact that in many cases a broken wire comes in contact with its neighbor, so that the circuit is again established. A part of the filament is thus cut out of the circuit, and the lamp consequently burns more intensely, and sometimes even too intensely, in which case, of course, only a short span of life is left to it. Yet we have had more than one lamp under observation, the filament of which broke for a first time after a short period of service and then broke repeatedly, but notwithstanding this the lamp lived more than 1,000 hours. We have often succeeded in rendering a lamp with a broken filament serviceable again by tapping it to bring the broken piece into contact with its neighbor. Fig. 8 represents the frame of a lamp in which the filament was burned through in three places, and yet continued to do service. For the sake of clearness, the back spans of the filament have been omitted in the drawing, while the front spans which were carrying the current are drawn in specially heavy lines.

It must further be mentioned that after serving for some time, say 200 to 300 hours, the tantalum filament loses a great deal of its mechanical resistance; while, as has been stated by Dr. Von Bolton, tantalum wire, when new, has a greater tensile strength than steel, it becomes brittle, and will break easily in the course of its life as a filament. It is therefore advisable when lamps have served for some time not to remove them from their old fittings and put them into new ones, as that might easily cause the filament to break. New lamps are not very sensitive to strong shocks, even while burning, but when this alteration in the filament has occurred it is well to preserve them from shocks.

The behavior of the tantalum lamp under a very great increase of voltage is of special interest to the incandescent lamp maker. As was to be expected, the trials made in this respect have also shown the superiority of this lamp over the carbon lamp. It has been ascertained that tantalum lamps for 110 volts, 25 Hefner candle-power and 1.5 watts per candle-power only burn through at 260 to 300 volts if the pressure is increased slowly and gradually, while with carbon lamps designed to work under the same conditions nothing like that figure can be obtained. The superiority of the tantalum lamp over the carbon lamp with regard to blackening of the glass globe can also be proved in a few hours by means of comparative burning tests at about 30 per cent overload.

Another advantage of the tantalum lamp over the carbon lamp is that the resistance of tantalum, like that of all other metals, strongly increases with the rise of temperature, while carbon is known to diminish in resistance when it is hot. In Fig. 9 the variation of the resistance of tantalum and of carbon as a function of the voltage is graphically represented, the pressure being assumed as 100 volts and the resistance at 100 arbitrary units when the efficiency is 1.5 watts per Hefner candle-power, so that for each per cent of variation of voltage the respective precentage of variation of resistance is shown. It will be seen in the first instance that the resistance of the tantalum increases to more than five times its original value from the cold state to 1.5 watts per Hefner candle-power, while the resistance of the carbon decreases to about one-half of its

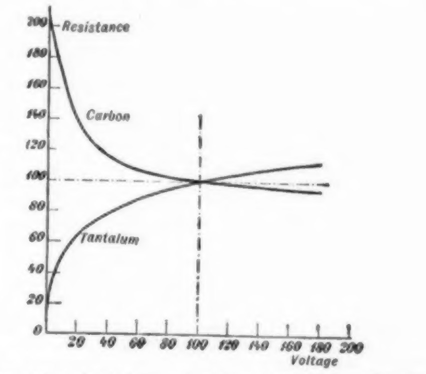


Fig. 9.—Variation of Resistance with Voltage of Tantalum as Compared with Carbon.

initial value. It will further be noticed that even afterward the resistance of tantalum goes on rising, while the resistance of carbon keeps dropping. Therefore the increase or decrease of pressure causes the strength of current, and with it the illuminating value, to rise or fall at a quicker rate in the carbon lamp than in the tantalum lamp, and, consequently, the latter is less sensitive to variations of pressure than the former.

Having thus related the whole history of the development of the tantalum lamp, and fully entered into a critical comparison between it and the carbon filament lamp, we need scarcely add that we do not intend, of course, to be satisfied with what we have already obtained. For the time being, however, and until a larger building has been erected for the production of tantalum, our firm has resolved to keep to the type for which there is an immediate practical demand. That is the lamp for 100 to 120 volts, which supplies 25 Hefner candle-power at 110 volts, or will have a higher or lower illuminating value if worked at correspondingly higher or lower voltages. In conclusion, I would recapitulate the properties which we claim as peculiar characteristics of our invention, as follows:

1. The tantalum lamp has a filament made of a metallic conductor and burns at once on being connected without any previous heating.

2. The light-giving wire is prepared by melting in a vacuum and drawing; it is tough even in the cold state, and can therefore be coiled and fixed in the lamp when cold.

3. A relatively great length of wire can be placed in a simple manner within a bulb of ordinary dimensions.

4. Tantalum ore exists in considerable quantities and can be easily procured.

5. Similar principles of treatment can be adhibited to other metals of a very high melting point.

The heavy work of the single-arc metal bridge for carrying the Paris Metropolitan Railway over the Seine a little above the Pont d'Austerlitz is now terminated, but it is not probable that this bridge will be opened before the end of the present year, because the completion of the line following the boulevards of the left bank is also dependent on the Passy bridge.

STEAM HEATING PRINCIPLES.*

By Prof. William J. Baldwin.

One may ask with a good deal of concern, "What are the principles of steam heating?"

To the backwoodsman who has a sawmill and who wants to warm his office or part of his premises, the principles are simple enough. He generally places a coil or radiator where he wants heat and simply carries steam to it from his boiler, in a small pipe, often without regard to alignment, blowing the waste out of doors and doing it with a certain amount of impunity, for the simple reason that fuel costs him little or nothing, often only the effort to put it in the boiler, and frequently he finds it cheaper to burn it than to cart it away; and again, all out of doors being generally his own premises, he has only himself to contend with if the waste water and steam become a nuisance upon the premises.

With the advance in the price of fuel, the restriction in area, and a consideration for the rights of your neighbor, the problem rapidly changes.

The first stage was to use a trap instead of a choke valve on the end of the return pipe, the object of the trap, of course, being to allow the water to run away but to retain the steam.

From the sawmill in the country we can swing to the other extreme—a fine private residence. The heating apparatus in these residences may be classified under three heads—a simple gravity steam apparatus in the perfection to which the art has brought it, a gravity hot water apparatus (which is a matter of choice or convenience or judgment as compared with the gravity steam apparatus), and the more pretentious apparatus in great mansions, where power is sometimes used and exhaust steam from engines used for heating.

A closed or gravity system of steam heating will be the first consideration.

There are three methods, the one of which usually followed is the simple gravity steam apparatus. The gravity apparatus is also known as a closed system. In other words, as it is impossible for steam to waste through the air cocks or air valves, there is no means of losing water from the apparatus except by a broken pipe.

In such an apparatus, the water of condensation from the radiators and the pipes returns to the boiler of its own weight, without the assistance of mechanical contrivances. Such an apparatus should have its pipes proportioned so that the water of condensation will return into the boiler at any pressure that it is safe to carry on the boiler. If the pipes are large enough, the water will return under any pressure. There is a size, however, below which it is not safe to go, if the pressure in the boiler exceeds, I will say, one pound pressure. Very small pipes indeed will do if the pressure in the boiler offers no resistance, or offers a very small resistance, to the inflow of the water of condensation, and this I hope to make apparent further on.

In the early days of the gravity apparatus, very little consideration was given as to why the water entered the boiler, and the sizes of the pipes then used were so small that when an accidental pressure in the boiler reached say, two pounds to the square inch, the apparatus began to fill with water, and a water hammer or pounding in the pipes resulted.

The engineer in those days, or the steam fitter, through his limited practice and experience, did not realize that the success in returning water to the boiler depended more on the diameters of the pipes than on anything else. He did know, however, that, as soon as the pressure advanced beyond what is usually found to be from one-half to one pound pressure, trouble existed, and very early he hit on the expedient of carrying a separate return pipe from every radiator vertically down to a return pipe very near the floor of the basement. Now this contrivance did afford him a measure of relief.

Each return pipe is separate down to the water-line and below it. Any inequalities of pressure entering these return pipes from the top must result in different heights of the columns of water within the return pipes. As these return pipes, however, were not branched, but ran from the basement floor, or near it, to the first, second, and third floors of the building and to the radiators on these floors, a column of water could run up in the return pipe, say for the second floor, above the level of the first floor without at all affecting the radiator on the first floor, for it had no connection with it. As long as this pressure was not sufficient to lift the water into the radiator, the radiator worked noiselessly and fairly well, because the extra head or pressure of water in this return pipe overcame the resistance of the steam within the boiler.

With the small pipes, the further one went from the boiler the less, of course, the pressure, the friction being so great. The pipes did, however, carry out some steam, but with a relatively great loss in pressure. In the boiler there might be only one-half pound—as was the rule 30 or 40 years ago—while at the radiator there might be only sufficient steam to expel the air. Therefore, the only means of getting the water to return to the boiler at all was by a well defined head in the individual return pipe.

In the case of the second story radiator, with two pounds pressure at the boiler, this head or column of water in the return pipe could not exceed a head of 54 deg., or just enough to balance 5 pounds at the boiler.

Under such conditions of course, in an ordinary apparatus, that is, with the heights of basements or cellars possible in ordinary residences, the radiator on the first floor would invariably stand full of water, even with one pound pressure on the boiler, for it is not sufficiently high above the water-line to have the head in its individual return pipe overcome the pressure in the boiler.

The fact, however, of the radiator being near the main (that is, the first floor radiators), the connection between the main and the radiator being short, these lower story radiators were favored in that their steam could reach them with less loss of pressure than a second or third story radiator.

This difference of loss of pressure, therefore, favored the lower story radiator, so that the steam in that radiator would push down and meet the water in the return pipe with some appreciable pressure, say one-half the boiler pressure.

This generally resulted in keeping the water down, even in the case of the first floor radiator, provided the pressure in the boiler could be maintained at one, or at the very most, two pounds pressure.

When I say "keep the water down," I mean that the radiator filled with steam, and that it probably did not often pound or give the water-hammer. I have attributed this good result so far to the fact that the steam connections were short, and the loss of pressure was less than when the steam had to be carried a greater distance to the second or third story, but I am of the opinion that my explanation does not entirely account for the cause of the warming of the radiator. Another principle may be said to have been at work. The radiators used in this class of work were always what are known as two-pipe radiators, that is, they had an inlet and an outlet, and that the inlet often acted as it does in one-pipe radiators, allowing some of the condensation to fall back again into the flow pipe, even against the inflow of the steam, which of course must take place in a one-pipe system.

Many of the boilers of the times were so arranged that it was not possible to get a pressure of steam in them that would exceed one-half pound per square inch above atmosphere. This was done by an open water column that would blow out if the pressure exceeded one-half or three-quarters of a pound, but more often by a safety valve that would be set for one-half or three-quarters of a pound pressure, so that it would be practically impossible to get any more pressure in the boiler, the excess blowing away. Of course automatic draft contrivances were used at the same time to anticipate the excessive pressure of one pound per square inch, but these did not always act, and a safety valve that would let out steam, and a water feeder that would let in water, were the expedients.

This went on for a comparatively long time in the early history of the trade, and even after it was discovered that by enlarging the pipes, that is, the steam pipes, that the trouble was very much less, or had entirely disappeared, the trade still adhered to the separate or individual return pipe running to the basement floor.

About the same time also, the makers of the old sheet-iron radiator that is occasionally found in an old hotel, particularly in Connecticut, came to the conclusion that they could operate steam at any pressure, or any reasonable pressure, if they simply carried a pipe from a boiler on a sufficiently upward grade to the radiator, and placed the radiator on top of the pipe, acting on the theory that it was utterly impossible to keep the water in the upper side of the vessel, no matter what the pressure was. This led to what is known as the one-pipe system.

We find its modification in connection with the more elaborate system where the building is of considerable horizontal magnitude.

From the individual return pipe system, there is developed the return pipe system common to all the radiators on a line.

With mains so large that there was an equalization of pressure within the entire system, what is known as the two-pipe system came into vogue. It is the commonest method found in buildings to-day, though for cheapness and other reasons is rapidly giving way to the modified one-pipe system.

In a modification of the one-pipe system, now rapidly coming into use where the building is not of too great a magnitude on the ground, the water that runs down the rising line and into the main is not carried backward through the main, but is carried forward in the main, moving always in the direction of the steam when once it leaves the rising line, and entering the boiler in the usual manner. The main pipe is a main pipe and return pipe, and must be always near the ceiling until it approaches the boiler or passes the last rising line where it may drop below the water-line and enter the boiler.

With a system like this, however, the main must be large, so that the drop in pressure between where the steam leaves the boiler and where the water returns to the boiler is comparatively small indeed. It often happens that for economy or similar reasons buildings are put up without basements or cellars, and a pit only is provided for the boiler. Something must be done in a case of this kind.

With low pressure of steam, it is safe to say that we are warming with mixtures of air and steam. A certain amount of air does come from the radiator through the air valve, but what remains after the air valve closes will be found to be a mixture of air and steam, the temperature of which, however, is very nearly equal, if not entirely equal, to steam at the same density and pressure.

An expedient sometimes resorted to when the return pipe cannot be gotten below the water-line is known as an artificial water-line. In a case of this kind, all the advantages are obtained that can be had by sealing the lower ends of the return pipes; of course I mean getting them below the water-line.

The remainder of the work in such an apparatus will not differ from that of the best form of gravity apparatus, so that a great deal that may be said hereafter in connection with the details will apply equally to this work and to all other pipe systems so far as the rising lines and other parts are concerned.

Changes in pressure and other causes, however, which it is not always possible to determine, force out the seal, on occasions, even with the pipe, and for this reason it is customary to put a valve in this pipe. If the valve is closed entirely, however, the water will at once siphon over, and if it is left wide open during a rapid increase in pressure, which sometimes follows a new fire, live steam will pass down through the pipe and get into the return pipe in more or less quantity, often sufficient to cause a water-hammer.

At first glance it does not seem quite clear how this steam can force its way down through the water in a seal of this kind, and probably it is right to suppose that it does not, and what probably does happen is that steam moves from this pipe into the return pipe, in a direction backward to the natural flow of the water, the reason for the same being that the pipes and radiators at a distance have not as yet received steam enough in the right course through the flow main to equalize the pressure, or nearly equalize the pressure, throughout the system.

The expedient, therefore, to guard against such a condition is to place a check valve in the return pipe, on what may be known as the house side of this pipe. A check valve of course offers some resistance to the flow of water toward the boiler, and as the flow of water toward the boiler is entirely produced by the head of water within the vertical return pipe, such a check valve must be of special light construction, unless the basement has a very considerable height. Basements of this class, however, where it is necessary to excavate for boilers, rarely have sufficient height to waste any of it. Therefore the check valve must be of an exceedingly good make, say a swinging check valve, and I have had to put aluminium flaps in them so as to make the action of the check valve inconsiderable.

In the pipe from the boiler to the first rising line of a typical gravity system there is a loss of pressure. It may be only equal to an inch of water, or it may be equal to three inches of water. If it is only equal to an inch of water, our pipes are ample indeed. If it is equal to three inches of water, our pipes are probably ample, but that depends entirely on the length we have to carry the steam horizontally.

No matter how large we make our pipes between the first and the second rising line, there will still be a loss of pressure; but if they are proportioned by the same scale that we proportioned the pipe between the boiler and the first rising line, the loss of pressure between the two rising lines will be just equal to the loss of pressure between the first rising line and the boiler, so that we may expect a difference of level of two inches at the second rising line, and as we must always consider that to carry steam beyond any point thereafter, such as to the third, fourth, fifth, or hundredth rising line, we are still losing one inch of pressure between each rising line, and that in the case of fifty rising lines, we would lose fifty inches of water pressure, which would probably be prohibitory, and the prohibition would be entirely due to the height of our cellar or basement, or more accurately still, to the height of our mains above the waterline of the boiler.

The further we have to carry our steam horizontally therefore the larger our mains must be, for should our limit be fifty inches and we had to carry steam to one hundred rising lines, then our pipes would have to be so large at the start that the loss of pressure between one rising line and another would be represented by only one-half inch of water.

It may run through your mind that one hundred rising lines on a single apparatus is very unusual and I will say that it is, but that fifty, after all, is not so very unusual.

For our purpose, however, it matters not how many rising lines we consider, excepting that the more we have, the harder our problem becomes.

With only twenty rising lines from the boiler (a very ordinary condition in large buildings) and with a loss of two inches of pressure between each rising line, the difference of level at the last rising line will be forty inches, which in itself would probably be prohibitory in an ordinary basement.

Advantage may be taken of the individual return pipe system to use only a single valve upon a radiator, and to make a fractional system of it, and by a fractional system I mean a system whereby little or much steam may be admitted to the radiator.

Of course the pressures must be low, say in the neighborhood of two pounds, for an ordinary building. In other words, the pressure must be so low that if one wants to use a radiator on the first floor on the fractional system, the water in the return pipe can never head up to the first story radiator.

A fractional valve is one that is graduated so that a person can with some degree of accuracy

* The second lecture of the course of eight on Heating and Ventilating delivered at the Brooklyn Polytechnic Institute's College of Arts and Engineering.

know the amount of steam he is admitting to the radiator.

When the steam is admitted in reduced quantities so as to graduate the heating surface, of course the pressure cannot follow it, and water will rise in the return pipes.

The column of water within the return pipe acts as a stop to the opposite end of the radiator, thus doing away with the necessity for a valve on the return end, the water performing that function.

A fractional or graduated system, one in which the radiator can be partly warmed, must be so arranged that the water of condensation can run away at the opposite end of the radiator without admitting steam through that end, and various devices have been designed for use at the return end, so that a fractional system could be obtained with a return pipe common to two or more radiators, but such devices have been failures in practice.

With the ordinary two-pipe system, where it is necessary to close the valves on both ends of the radiator to at all interrupt the steam (it is well to say here that nearly all steam radiators with a valve at opposite ends require that both valves should be closed tightly when steam is to be shut off, and that both should be opened to their fullest extent when steam is required) a fractional valve should be substituted and the return pipes run individually below the water-line. Check valves will not do. I want to caution all steam fitters, or those who design steam apparatus, to avoid a return pipe that will cross the water-line of the boiler.

One who has not given the matter much consideration is very apt to think that an accelerated pitch in a pipe is going to materially assist the water to move toward the boiler.

If the pipe is a dry pipe and can always be kept dry, a downward pitch in the direction of the flow will of course accelerate the flow of the water, but nothing particular is to be gained by acceleration, as the pipe is generally sufficiently large to carry the water along as in an open drain, practically as fast as it is formed.

It is to guard against making an extraordinary effort, therefore, in an apparatus of this kind, to get an increased pitch in the return pipe where it can possibly do no good, and where it may do a great deal of harm, that I am drawing your attention to this particular point.

The lower pipe is an example of the condition that I desire to warn you against. Any return pipe that occupies a position such that the water line crosses it is sure to make noise continually or periodically, due to slight changes of condition in the apparatus.

Should the differential pressure between the flow pipe and the return pipe vary, the water in the latter will change its level, and by changing its level it will run back and forth in a pipe that usually is nearly horizontal.

The water line might always be safely above the foot of the first rising line and cause no trouble at that point, but at the second rising line the water line within the return pipe will vary, due to the inequalities of pressure which I mentioned before, so that at one time it is a little above the lower end of the return riser and at another time it may be below it. In any case the water will run back and forth in considerable quantities, for the simple reason that the pipe being so nearly horizontal, it forms capacity enough to receive it. Therefore the return pipe of an apparatus, if it must be above the water line, must be so far and safely above the water-line of the boiler that the water can never back up into it, or, what is better still, it must be so much below the water line that it can never become empty.

It is sometimes impractical to get this slightly downward grade toward the boiler. Buildings are long and the trenches cannot be made sufficiently deep to give them a pitch. Therefore if the work is made "dead straight," it will do, provided the vertical return pipes always enter the nearly horizontal return pipes at the top.

An effort must be made to prevent air accumulating in this nearly horizontal return pipe. If the pipes are dead straight, the air will escape up the return rising lines. If the return pipe is pushed up in the middle between two return rising lines, air can separate at the high point, and this is sure to cause trouble, as the air will separate at the high point and hold up the return water in a measure that seems incomprehensible. Any plumber who has attempted to pass water through two consecutive running traps in a nearly horizontal pipe can vouch for the assertion I have made, although he may be at a loss to account for the extraordinary results of air binding in return pipes.

Should the return pipes sag in the opposite direction, no harm is done, as then the air escapes through the return rising lines, and the pipe will not be air bound.

It frequently happens in basements of buildings, where trenches are not provided, that the steam fitter will conceive the idea of running his return pipe on a very big pitch on the side wall crossing the water level.

The cure, of course, is to drop the return pipe sufficiently so that it will not cross the water level.

From that part of the apparatus known as the horizontal mains, which includes the flow and the return pipes, we can logically pass to the rising lines, their connections and their valves.

All rising lines should, if possible, leave the steam main at the top, and it would be well to have the return rising lines enter the return main at the top also, but trenches and other methods of construction may prevent this, so that the best we reasonably can do is to enter the return mains at the side.

The drip is from the heel of the steam riser.

This is the usual method of connecting it, below the water line, with the return rising line.

The criticism I will make on the method, is that it requires three valves, one in the steam pipe, one in the return pipe, and one in the relief pipe.

The valve in the relief pipe is a simple choke valve, and no valve but a globe valve should be used as a choke valve.

In a great deal of work the valve in the relief pipe is entirely omitted, but if it is omitted it will often be found that it will not satisfy the engineer who has to operate the building after the designing engineer has turned over the work. He will often get the idea that he is losing steam from the steam rising line into the return pipe. Now this is not so, but if the valve is not put in the pipe, the engineer who has designed the work is very apt to feel the criticism, so that for his own protection he puts the valve in, and leaves it to the engineer who takes charge of the building to operate it properly. Usually it is operated by being "cracked" off the seat, and presumably this is the best way to operate it. Admitting that it is the best way to operate it, of course admits the necessity for it. It is best, however, to put it in.

The rising line of the individual return pipe system has two valves only, and none in the drip from the heel of the steam rising line. In private house work, this is an admirable method to follow. It is the method also that would be followed in very low pressure work where the *fractional valve would be used.*

In high buildings, the expansion of the rising lines is of the utmost importance.

With the old wooden building of not more than four stories with the chance of putting the radiator connections in the floor thickness, and of making comparatively long connections between the rising line and the radiator, or of doubling back and making a spring piece under the floor, the question of expansion of rising lines was a negligible quantity.

In high modern buildings, however, it is a matter that must be carefully looked into, and unless properly worked out may be a source of endless trouble and anxiety.

An iron pipe expands or contracts, in rough numbers, the 1/150000th part of its length for each degree Fahr. it is warmed or cooled, so that in a building 200 feet high this movement may be five or six inches under ordinary conditions of temperatures and pressures, so that if it was held at the bottom and the movement was upward, the rising line would practically grow five inches out of the floor as steam was turned on. This of course is prohibitory. The next idea, therefore, is to anchor the line in the middle and force one-half of the expansion upward and one-half of it downward, but this will cause trouble, as it is not always possible to force 2½ or 3 inches down upon the rising line connection, for the simple reason that it would disturb the alignment and adjustment at the lower end of the rising line.

In buildings five stories high, this can be done, that is, anchor the rising line in the middle and force the expansion up and down.

In a high building it cannot be done. The rising line must be anchored at least at two points.

In the case of the Temple Bar Building in Brooklyn, I anchored it at two points, and used expansion joints at two points. This reduced the movement at any particular floor to something considerably under one inch, and this is easily taken care of by the spring of the radiator connection. In other words, the radiator connection is long enough not to break under the strain put upon it by say ¾-inch of movement. This is a very common condition and has to be met and overcome in nearly all radiator connections.

There is no trouble in designing or providing a suitable anchor. Often it is nothing more than a heavy clamp, fastened about the pipe, and concealed in the floor thickness. This, however, interferes with the floor tubes and has its objections.

The selection of an expansion joint requires considerable judgment as there is nothing on the market really suited for a rising line.

The ordinary slip joint (the common form of expansion joint) must be repacked every year, and this in itself seems to make the use of such a joint prohibitory, for the reason that they are never packed until they begin to leak, and under any considerable pressure they are always leaking.

I used these joints in the Tribune Building, the first very high building erected in New York.

In the Temple Bar Building I used a corrugated expansion joint, entirely free from packings. The same joint was also used in the Manhattan Hotel, but in both instances it gave trouble by cracking. The principle is good, however.

They are made of light brass, on the accordion principle, sufficient to withstand the pressure, but not always perfect enough or the metal elastic enough that it would not crack or develop leaks, hence the steam fitter is forced to the use of a spring joint, and by a spring joint I mean a loop of pipes. The loop is sometimes concealed within the floor thickness, and sometimes it is exposed near the ceiling.

It is up to the ingenuity of the engineer, therefore, to provide a spring piece that will be the least objectionable and accomplish the results.

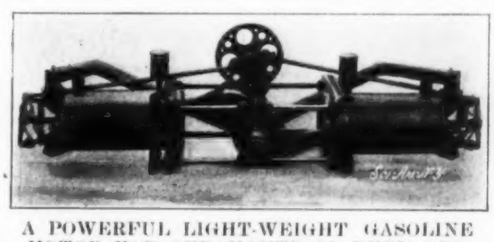
In the Hoe building on Broadway, entirely fireproof, the floor arches were masonry. Between the masonry and the finished floor there was no room for such a contrivance as a spring joint. In fact, there was not proper room between the top of the iron beam and the underside of the finished floor for the radiator connections, so that with the architect's permission I designed a box of cast iron to take the place of part of the brickwork in the masonry arch, and within this box concealed the spring piece.

In such a contrivance, of course, there is danger of leakage, but some risk must be taken, and the rising lines were subjected to considerable pressure, say not less than 100 pounds per square inch, cold water pressure, although the pressure that was to be carried on them eventually was often no more than the back pressure of the exhaust steam, say a limit of two pounds per square inch.

The boxes were constructed, however, so that they could be opened and inspected and even repairs made without disturbing the arch, by simply removing the wooden floor, which was paneled for that purpose.

A POWERFUL LIGHT-WEIGHT GASOLINE MOTOR FOR AERONAUTICAL PURPOSES.

The accompanying engraving shows a two-cylinder motor recently constructed by the Duryea Power Company, of Reading, Pa. Completely equipped, ready to run, without batteries, it weighs just under 100 pounds. Stripped of water and fuel tanks, carbureter, and ignition apparatus, as shown in the photograph, it weighs 90 pounds. It develops a maximum of 16 horse-power on a brake test. The inlet and exhaust valves are placed in the head and clamped in position by a single nut, which makes them readily removable. The bearings, crankshaft, and wearing parts are fairly large, so that the motor, although quite light, ought to give very good service. It is shown without flywheel, as the propeller to which it is attached serves this purpose. The cylinders are opposed, 4⅝-inch bore by 5½-inch stroke, jacketed with cylindrical copper jackets.



A POWERFUL LIGHT-WEIGHT GASOLINE MOTOR FOR AERONAUTICAL PURPOSES.

THE UTILIZATION OF WASTE ENERGY.

"While much has been done and much more is being done at waterfalls and river rapids, large and small," said C. M. Woodward at St. Louis, "the work of saving the energy which now runs to waste has but just begun. When the great waterfalls are utilized the rapids will remain. We are lost in wonder when we calculate the possibilities. Measure the volumes which rush over the 'Sault Ste. Marie,' as the waters of Lake Superior drop to the level of Lake Huron; and then again put your measuring rods into the vastly greater volumes which plunge and rush from Lake Erie to Lake Ontario; and still again through the rapids of the St. Lawrence to the sea level. At every vantage ground, the work of utilization has begun and no man now living will see that work stop. Turn next to smaller streams and mountain torrents—what fields open up to the hydraulic and electric engineers! Mountain reservoirs will serve the triple purpose of preventing destructive floods, of saving the energy for useful work, and of aiding irrigation. At every count the doors open wide for the best of engineering enterprise and the best of engineers, hydraulic, mechanic, electric, irrigation, and the echo of each department must be heard in the engineering lecture-room and laboratory. The electric transformer has made the transmission of energy possible from mountain slopes to far cities, and has unlocked bewildering amounts of energy at thousands of points hitherto deemed inaccessible. No one can see far into the future, but we all easily see the dawn of a new era of energy-saving. The streets of this city may yet be lighted by the energy which now runs to waste at Niagara. In St. Louis we look to the slopes and canyons of the Rockies for our supply of sweet, wholesome water—we may yet look to the same regions for the energy to drive our cars and run our mills."

Protecting Metallic Articles with Varnish.—This means protecting the surface from the atmosphere, and is often done by rubbing it with grease at intervals, or with special fatty mixtures. This treatment is not, however, to be recommended. The fat if not sour at the time of use becomes so eventually, and attacks the metal it is intended to preserve. Vaseline is not open to this objection, but like fat it is apt to be easily rubbed off projecting places, and like fat it makes dust cling to the metal. A varnish obtained by dissolving wax in turpentine is useful. It gives a fairly hard, invincible coat, but has the drawback of filling up fine grooves, and so injuring the appearance of many metal ornaments. The following two recipes give varnishes which answer every purpose: 1. Shellac, 15 pounds; Siam benjamin, 13 pounds; alcohol, 80 pounds; formyichloride, 20 pounds. 2. Sierra Leone

copal, 6 pounds; dammar, 18 pounds; oleic acid, 3 pounds; alcohol, 40 pounds; oil of turpentine, 20 pounds; formylchloride, 15 pounds. The formylchloride not only gives the rapid drying necessary to prevent the varnish gravitating into hollows, but enables the alcohol to make a perfect solution of the resin. The varnishes are excessively volatile, and must be stored accordingly.—Farben Zeitung.

A NEW BELGIAN PROCESS OF MANUFACTURING WELDLESS CHAINS.*

By Emile Guarini.

One of the most frequent causes of the breakage of chains is imperfect welding, which often occurs, as this operation is left entirely to the care of workmen; and so the attention of manufacturers was some years ago directed to the subject of the production of chains with weldless links. The first attempt made in this direction was that of M. Oury, a Frenchman, who took out a patent along about 1881. The process that he devised was soon taken up by others, who introduced into it certain modifications of greater or less value. Among the methods derived from that of M. Oury may be mentioned the Girlot and Castin, the Rougier, the Klatte and other processes, none of which proved practicable because of the high cost of the product, resulting from the multiplicity of the operations that were necessitated by the work, which started with bars of soft steel of a cruciform section and was effected by a series of successive stampings.

These manifold drawbacks seem to have discouraged inventors for a certain length of time, and it is only within a few years that an entirely new method has been proposed, and that is the Belgian process of annular rolling, due to M. Massin, long a resident in a region in Belgium in which the manufacture of chains is concentrated.

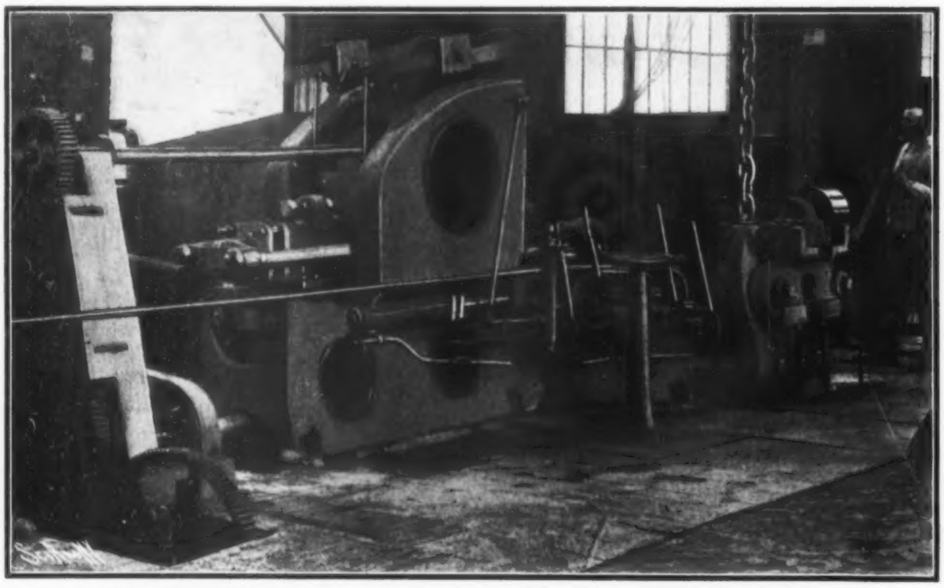


Fig. 1.—APPARATUS FOR THE MANUFACTURE OF WELDLESS CHAINS.

We shall not dwell upon the various stages through which this invention has passed, but shall merely say that the first apparatus devised was a simple "winder" that permitted of introducing into a link already formed a strip of metal in superposed coils. To this rudimentary apparatus was soon added a finishing roller. In short, the arrangement, having been gradually improved and simplified, now constitutes a complete system, of which we shall endeavor to give our readers a succinct description. The principle consists in winding under pressure, through the last link of the chain in course of manufacture, a flat iron previously raised to a white welding heat.

The work is performed by means of three special machines—a winder, a finishing roller, and an ovalizing press. As a matter of fact, the chain is not, properly speaking, weldless, but one in which the welding is done mechanically. Let us remark at the outset that the object aimed at is the doing away with expensive intermediate manipulations and the avoidance, especially, of reheating. Proceeding to the winding of a ring, it is well to brace the preceding one. A subsequent placing of the brace would, in fact, necessitate a reheating. The rough shaping by means of the winding roller requires, for this reason, great precision. It gives a ring of rectangular section in which the welding of the superposed coils is already begun.

A bar rolled flat and then beveled is heated to the temperature desired, in a furnace, from which it passes into the winding roller. This latter consists in principle of a mandrel around which the winding is done under the action of two external compressing cylinders and a guide. The cylinders are submitted to the action of a counterpoise which draws them toward the mandrel and, at the same time, permits them to move away from the latter in measure as the operation proceeds.

The winding apparatus weighs 1,320 pounds and is capable of rough-shaping fifteen links of iron, 2.3 inches in diameter, per minute.

* Specially prepared for the Scientific American Supplement.

In order to permit of the introduction of the last link of the chain in course of manufacture, the mandrel is provided with an elongated channel, and receives two internal actuating rollers. Thus prepared, the link is submitted to a second operation which gives it a circular section. This part of the manufacture is effected in a finishing roller in which it is submitted to the action of three semi-circular channeled rollers. These latter, one of which is stationary and the two others are movable, flatten the ring externally while embracing and holding it tightly.

The distortion of section that intervenes produces a genuine kneading of the bars, which thereafter form a homogeneous whole.

While the external rolling is taking place, a mandrel rising and descending under the action of hydraulic energy and provided with a half-round channel flattens the piece internally. The roller carriages also are controlled hydraulically. The movable rollers, in fact, are mounted upon two carriages that always occupy a symmetrical position with respect to the stationary roller, on one side and the other of which they are capable of displacing themselves in unison.

The link, before it is completely flattened, and previous to passing into the ovalizing machine, is submitted to a third operation, that of trimming. The object of this is to remove the two median seams that remain upon the circumference of the ring, above and below, after the piece has been laminated externally and internally. This operation is performed in the finishing-roller machine itself. With this object in view, one of the movable rollers of this apparatus is provided with two circular knives, which, during the laminating, are separated from the grooving in which the seam is produced. At the end of the operation, these knives approach each other and in an instant and simultaneously remove the excess of the metal from all parts of the ring. For the performance of this operation the workman has within easy reach a handwheel placed at the right of the machine, which permits him to raise and lower the trimming knives at the proper moment. It is likewise to the right of the machine that are placed the principal levers that actuate the distributers.

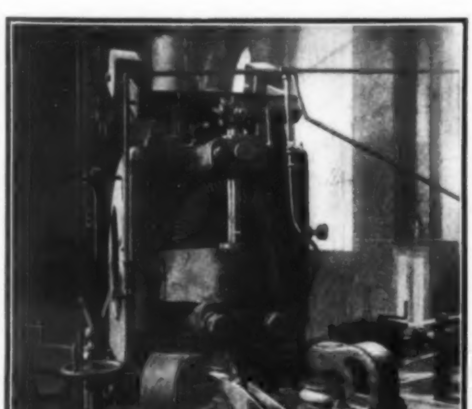


Fig. 2.—ROLLING MACHINE FOR THE MANUFACTURE OF WELDLESS CHAINS.

All the motions of the finishing roller are regulated in both directions by tappets that permit of giving them all the precision requisite.

The ring, which, owing to the rapidity with which the work has been performed, has not had time to cool passes finally into the ovalizing machine, in which two operations are performed simultaneously—ovalization and the placing of the brace. The link, now finished is then placed in the winding roller, where a new link is added to the chain.

Fig. 4.—RING ROUGH-SHAPED AND LINKED AFTER THE FIRST OPERATION PERFORMED WITH THE WINDING ROLLER.

The different apparatus that we have just examined are arranged one after another and in a line with the furnace. The various operations are performed with great rapidity, so that there is need of but a single heating, even for chains of very large size. On the other hand, the space required by the apparatus is relatively circumscribed, and the installation can be operated by a small number of workmen. The efficiency is thus found to be excellent.

By way of example, we may state that a complete installation requiring the employment of five men can easily turn out forty 1.4 to 2.4-inch links an hour. The five persons necessary are: a boy to raise the furnace door, and the lever of the winding machine in order to disengage the ring, and afterward to place the laminated ring in the ovalizing press; a machinist for the finishing roller; an assistant for removing the ring from the winding roller and introducing it into the following apparatus; a workman for putting the bar into and taking it out of the furnace, and for operating the ovalizing press with the aid of a boy, for manipulating the distributer, and, finally, for placing the link in the channel of the winding roller; and a stoker.

The annual production of such an installation, the cost of which is less than six thousand dollars, is estimated to be over eighty thousand dollars. To the advantage of simplicity and the celerity of the work is added, independently of the abolition of welding, the generally better quality of the links manufactured by the process. This superiority is the natural consequence of the method of manufacture which, so to

Fig. 3.—WINDING ROLLER.

Fig. 5.—AN ISOLATED LINK AFTER EACH OF THE THREE OPERATIONS.

speak, averts all causes of breakage, except, of course that due to the crystallization of the metal under the influence of vibration during the utilization of the chain. We may see, in fact, that every section exhibits several weldings comparable to those of bars of rolled iron. There is no transverse welding.

As has been seen, the link is formed from a thin

strip of metal wound hot and submitted, at a white welding heat, to kneadings which bring about the welding of the different parts. Now, the fact that this thin strip of metal is able to resist rolling in the first place and winding in the second is a certain proof of the excellent quality of the iron employed. We may be certain of the strength of the link for another reason still. In an ordinary chain, it may happen that more or less of the mass is of poor quality and may thus eventually give rise to an accident. Allowing even that a defect in the homogeneity of the bar has passed unperceived, that is to say, that the metal has withstood the work without breaking, it is evident that, since the bar represents in thickness only a very small part of the diameter of the chain, the defect could attain in the latter but a minute fraction of the section.

Such is the solution found in Belgium of the important problem of the manufacture of chains, giving all the guarantees of safety required—a problem which is not only economic, but humanitarian, since the human lives that depend upon the quality of a common chain-link are extremely numerous.

PHOTOGRAPH OF ELECTRIC SPARK.

PERHAPS it is not exactly correct to describe this as a *photograph*, since light plays no part in its production. It may more properly be called an "electrograph." The manner in which such representations of electric discharges are produced is as follows: An ordinary photographic plate, inclosed in two light-proof paper bags (as used in X-ray work), is placed film upward on a metal plate, which is insulated. The pointed dischargers of an induction coil, in this case one giving a 10-inch spark, are placed a few inches apart, touching the paper envelope. The circuit is then closed, and a single discharge brought about by holding the hammer of the coil and letting it go suddenly. The spark in its passage through the sensitive film decomposes it. The negative is then developed in the ordinary way. Variations of many kinds may be made by dispensing with the metal plate, or by placing the wires one above and one directly below the negative, or by using knobs on the dischargers instead of points.

One of the most interesting points to note is the difference between the positive and negative discharges, the former being "tree-shaped," while the latter is feathery or "fan-shaped." With a single spark both structures are often shown, owing to the oscillatory nature of the discharge. The photograph here reproduced was taken by Mr. Hudson, of Harringay, and originally published in Knowledge.

SPARK ELECTROGRAPH.

DEVELOPMENTS IN HEAVY ELECTRIC TRACTION.

JUST at the present time, the developments in heavy electric traction are attracting more attention than any other subject in the electrical field. A great amount of published information is available for those desirous of studying the history of electric railways, but the present condition of the subject, as viewed by those whose labors have developed this situation, is not so easily learned. For this reason attention is drawn to the following abstract of a paper read before the New York Railroad Club on January 20 by Mr. W. B. Potter, of the General Electric Company, which states the opinions held by that corporation on the future of electric railway operation.

The most profitable method of handling a distributed passenger service, Mr. Potter pointed out, is by running many short or long trains as the case may be, at frequent intervals, whereas with steam locomotives it is the general practice to deal with the traffic with only long trains capable of conveying a very large number of people at one time.

This fact shows very forcibly that in a number of instances where the traffic is of a concentrated nature at the present time, and, therefore, considered as unfitted for being handled electrically, were an electric system installed, the traffic would naturally change from the concentrated to the distributed form.

A great deal has been written concerning the possibilities of single-phase traction and, as is often the case with the development of a new principle, many appear to have formed too optimistic ideas of its capabilities. While Mr. Potter recognizes the advantage of such a system in many cases, he believes it is a mistake to imagine that it will be a cure for all ills and revolutionize the railway world. The single-phase alternating current system possesses two features which recommend its use—economy of trolley copper, due to the higher trolley voltages, and the elimination of the rotary converter. The chief advantage gained by these features, which increase in importance in proportion to the amount of power required by each car or train and with the length of the trolley line, is a saving in the initial cost of equipment. On the other hand, the alternating current car equipments cost more than the direct current equipments for a similar service and the same given rise in temperature of the motors. It is, therefore, apparent that the relative cost of an alternating current or direct current system will be materially affected by the number of cars employed.

The saving in power resulting from the elimination of the rotaries is about offset by the greater weight and slightly lower efficiency of the alternating current motor.

The efficiency of the alternating current control, during acceleration, will, generally speaking, be somewhat higher than that of the direct current system with series parallel control. With the alternating current system fractional voltages can be obtained from the transformer on the car. Each step of the alternating current controller gives a running position which corresponds with the series and parallel positions in a direct current controller.

The potential of the transmission lines from the power station may be selected, as in the case of the direct current system, without reference to the trolley or secondary voltage. The trolley voltage must, however, be considered from a different basis than that of the direct current system for the reason that in addition to the ohmic resistance of the trolley and track circuit, there is an apparent increase in resistance, due to the alternating current. This increase in apparent resistance for 25-cycle alternating current, as compared to direct current, is about 50 per cent in the trolley wire and between six and seven times greater in the rail return. The rails being steel, the increase in apparent resistance is relatively much greater than in the trolley wire. As the resistance of the track return with large steel rails is proportionately much less than that of the trolley wire, the apparent increase in resistance for the latter and the track taken together will be, roughly, from one-half to twice that for direct current. An alternating current at 1,000 volts is therefore about equivalent to 600 volts direct current so far as affecting the amount of trolley copper, and to secure the advantages of the alternating current system to a reasonable degree at least 3,000 volts or, for heavier service, perhaps 5,000 volts must be employed.

The equipment of heavy locomotives with alternating current motors for high speed passenger service is a possibility, but owing to the limitations imposed by the space available for the motors, it seems probable to Mr. Potter that two locomotives, each with four motors, would be required for service which could be performed by a single direct current locomotive with four gearless motors. For locomotives in slow speed work, such as freight or shifting, a double gear reduction will, in many cases, be required, owing to the difficulty of winding an alternating current motor of large size for slow speeds.

In view of the extensive application of the direct current system, it is fortunate that the alternating current motor and its control may be so arranged as to be well adapted for operation on either high potential alternating or 600-volt direct current lines. This adaptability is an important factor in the net earnings as the equipments are not necessarily limited at all times to a particular route; and further, where direct current trolley lines are available, the expense of installing a special alternating current trolley is saved.

The above comparisons relating to alternating current and direct current systems indicate certain financial and technical differences which have to be met. There is no question as to the successful operation of alternating current apparatus, Mr. Potter says, and the advisability of its use when such an installation will prove financially advantageous.

The power required per ton mile for moving trains varies so greatly with conditions of traffic that any direct comparisons between electricity and steam as a motive power can only be made by assuming a given class of service. The suburban type of traffic is generally recognized as being more especially suited to electrification, and a comparison in such service of the steam locomotive and an electrically-equipped train of equal seating capacity was made by Mr. Potter, which may be summarized in the following table:

	Steam.	Electric.
Coal or equivalent electric power	14.5	10.3
Water	.5	..
Train crew	12.0	6.7
Maintenance	6.5	4.0
Supplies	.5	.2
	34.0	21.2 cts.

Assuming a yearly mileage of 50,000 miles, which is a reasonable assumption for the electric train, the yearly difference in cost of operation, in favor of electricity, would amount to $6,400, representing an interest on the total investment per train which would be more than sufficient for that usually required for the car equipment and the proportionate part of the power station and transmission. Furthermore, to this capitalized investment should be credited the cost of a steam locomotive equipment capable of making 50,000 miles per year. As this is a brief consideration of a general example, it is hardly worth while to enter into refinement, but in nearly every case the use of electric power will make it possible to secure many incidental economies, both in utilization of rolling stock and cost of operation, the aggregate of which may be a large item.

Careful calculations should be made on each individual road considering electrification, as actual results will vary with every new set of conditions. The point at issue is whether the traffic is, or is likely to be, of such a character that the saving in operation or increased receipts will show a proper return upon the required capital.

In considering the application of electric power to freight service, the subject may be considered more strictly from the standpoint of existing traffic, as the reasons which influence the growth of passenger traffic will apply only in so far as the movement of freight may be facilitated and cheapened. Electric power in a single unit, such as a locomotive, is best suited for general freight, although there may be special cases where it will be advantageous to equip several or all of the cars in a train and control from the leading car.

As with the steam locomotive, the design of the electric locomotive is influenced by the service for which it is to be used.

The bogie truck type following the precedent of the motor car was the first to come into general use and it has become a well-established type for general service in high speed haulage, or for yard shifting where there are many curves.

The articulated type is well represented by the locomotive originally supplied to the Baltimore and Ohio Railroad for the Baltimore tunnel. This type is much the same as two coupled locomotives with the disadvantage of not being two independent units, either of which can be operated or repaired independently of the other.

The rigid frame type is one in which all axles are held square with the frame and parallel to one another. The mechanical design is strong and simple and well adapted for heavy slow speed haulage. The additional equipments for the Baltimore and Ohio tunnel are of this type. Two of these locomotives, with a total weight of 160 tons on the drivers, are ordinarily coupled together and controlled as a single unit.

The requirements of high speed passenger service are especially severe, demanding a locomotive of large power and consequently of heavy weight, as well as one possessing a reasonably flexible wheel base.

The locomotive recently designed and built by the General Electric Company and the American Locomo-

tive Company for the New York Central Railroad is the result of a careful study of many different types. This electric locomotive differs from any that have previously been built, in having a rigid frame for the drivers and pony trucks at each end for guiding.

The method of conveying electric power to a car or train is influenced by the size of equipment and conditions under which it operates. The simple trolley and wheel in general use has been surprisingly satisfactory in service much more severe than that for which the trolley wheel was originally considered. The limitation of its capacity is rather in the life of the wheel than from any particular difficulty in collecting the current. With cars of medium size, at moderate speed, an upward pressure of 15 or 20 pounds against the trolley wire is sufficient and the life of the wheel is frequently 10,000 miles or over. At car speeds of 50 to 60 miles an hour an upward pressure of 35 to 40 pounds appears necessary to insure the wheel maintaining close contact with the wire over the irregularities of the suspension. This greater pressure, coupled with the larger amount of current commonly taken at such speeds, results in the rapid wearing of the trolley wheels, which is more especially noticeable on account of the large daily car mileage common to high speed service.

Considerable attention is being given to the development of a collector for heavy service which will cost less to maintain than the present trolley wheel. The bow form of trolley in which a sliding bar of copper or aluminium at right angles to the trolley wire replaces the trolley wheel, has been used to some extent abroad and seems to have met with considerable favor. The cars on which the bow trolley has generally been used are of comparatively slow speed and power, and such tests as have been made indicate that in the equivalent of our suburban service the maintenance of the bow trolley would considerably exceed that of the trolley wheel. A modification of the bow trolley in which a roller replaces the sliding bar has been used in a number of cases with excellent results. Where the trolley wire is maintained within a foot or two of uniform height, a reversible trolley contact with a pantagraph mechanism, carrying a roller for contact with the wire, can readily be applied. Where the variation in height of the trolley wire is considerable, on different parts of the same line, the pantagraph construction must necessarily be of considerable size. The first electrical equipment of the Brooklyn Bridge was provided with this pantagraph form of trolley, prior to the installation of the third rail. It is customary to install two pantagraph trolleys, each collecting its share of the current; and where necessary to collect a larger amount, as might be the case in locomotive work, additional trolley contacts may be installed to any extent required. A pantagraph type of trolley, provided with a shoe, instead of a roller, is well adapted for use in connection with third rail operation, where it is desired to make contact through special track work or road crossings where the third rail cannot be conveniently installed.

The ordinary methods of trolley wire suspension and insulation are not well adapted for high potential alternating trolley lines and what is known as a catenary suspension of the trolley wire will probably be more generally used. In the catenary suspension the supporting cable or catenary is carried over the top of high potential insulators at the point of support and the trolley wire is attached by clips and hangers directly to the catenary without intervening insulation. The catenary thus serves as a supplemental conductor to the trolley wire and it may be of either steel or copper. As the trolley wire is supported at frequent intervals, the poles for the catenary can be spaced at longer distances than common with the ordinary type of trolley construction. While especially advantageous for high potential work, there is no reason why the catenary form of suspension should not be more generally employed for direct current work, as it provides a means for supporting a larger trolley wire, if desired, than is now commonly used.

The third rail, although used to a considerable extent in place of the trolley, has been criticized, particularly from the standpoint of danger and trouble from sleet. The unprotected rail is open to both these objections, but with a suitable protection against accidental contact and from sleet, these objections are to a great extent overcome.

The location of the third rail, with reference to the track, would seem to be a simple question, but owing to local conditions, nearly every installation has been different. Between clearing the low pressure cylinders of compound locomotives, the hoppers on the large steel coal cars, and keeping within the bridge abutments and tunnels, the location is generally a case of compromise. It will be advantageous to facilitate the interchange of equipments by establishing a uniform location of the third rail and the importance of such a standard and difficulty of finally determining it will increase with every new installation.

The subdivision of the third rail into sections which will be normally disconnected from the supply circuit and automatically connected when in the immediate vicinity of the car, has many times been proposed. Such an arrangement appears to have little or no advantage, as apart from the complication introduced, the sectional third rail should be protected by a covering to the same degree as an ordinary third rail. Unless the sections are very short, the rail will be energized for some distance beyond the car, and persons getting on or off, or working about the car, would be likely to receive shocks, and more especially so as the rail would ordinarily be considered harmless. Another important reason for protecting the rail is that the cover will form a shield from sleet, which is much more troublesome on a sectional third rail than on the ordinary third rail.

The third rail contact shoe, which has been quite generally used, depends on gravity for its contact with the rail; therefore, at high speeds with any unevenness of surface of the third rail, this type of shoe shows a disposition to jump and arc excessively. A better form of shoe is one in which the contact is held against the third rail by a spring, this principle being applied to the hinged type of third rail shoes in use on the Interborough Subway and New York Central locomotive.

The initial expense of electrical equipment, more especially that due to the cost of power station and trolley line, has deterred many steam railroads from electrifying branch lines in sparsely populated districts. Such lines could be served more profitably by independent cars than by steam trains, as the possibility of economically operating single cars on frequent headway, by providing a better service, would have an important influence upon the development of the traffic.

To meet the requirements of this class of service, a self-propelled car, independent of any feeder system, seems particularly well suited. With this end in view there have been numerous schemes suggested and tried, some employing steam and others compressed air as a motive power; and again, storage batteries and gasoline engines have been used. Without discussing the relative merits of these different methods, it may be briefly stated that the gasoline engine seems to have the advantage of possessing the greatest power for a given weight, and is also able to cover considerable distances—owing to the concentrated nature of the fuel and the high efficiency of the engine in relatively small sizes.

A number of such equipments are in operation abroad, some being provided with a mechanical transmission to the wheels similar to an automobile, and others having a generator direct connected to the engine, with the electric motors mounted on the trucks in the usual way. For cars of the weight commonly used on steam railroads in this country, and those which have bogie trucks, the gasoline-electric combination seems in many respects the better suited.

The principal difficulty that has been experienced with this type of equipment is the insufficient capacity of the engine; and this is not surprising when we appreciate that the motors of a 40-ton electric car under ordinary service conditions are frequently required to develop 500 horse-power during acceleration. The building of a successful car of this description is a problem depending entirely upon the engine; and there seems reasonable ground for the belief that an engine well adapted to this class of work can be produced.

The General Electric Company have under construction an equipment of this character which, if successful, should be well adapted to meet the requirements of the class of service under consideration. This car is provided with passenger, smoking, toilet and baggage compartments and is 65 feet over all. The engine-room is at one end and a motorman's compartment is provided at each end of the car, to permit its being operated in both directions. The car complete will weigh, approximately, 55 tons.

The engine will have a full load output of 200 brake horse-power and will run at 600 revolutions. It will be direct connected to a 600-volt generator, the fields of which will be separately excited from an exciter driven by the engine. The controller for the motors will be provided with a series parallel switch, but no starting resistance, in the usual sense, will be required, as the speed of the motors will be regulated by controlling the voltage of the generator through field resistance points in the controller. The water-cooling system for the engine will be carried through radiators on the top of the car during the summer, and in the winter through the ordinary heater pipes for the purpose of warming the car. An engine of the size proposed will provide for an acceleration sufficient to maintain a schedule speed of 20 to 25 miles where stops are three to four miles apart and the car can be easily maintained at a running speed of 40 miles. There is no data on which to accurately base the operating cost of such an equipment, but it seems probable that including all expenses—of the motorman, conductor, fuel, and maintenance—the cost will be between 15 to 20 cents per car mile. This will depend somewhat on the daily mileage made by the conductor and motorman, as their wages amount to a considerable portion of the total expense. Reference has been made to this type of equipment, because considerable interest appears to exist regarding the possibilities in this direction, but what measure of success will be attained can only be determined by a thorough trial. Several different types of engines are under consideration, as is also the use of kerosene as a fuel. The object in view is to produce an equipment comparable in some respects to the all-electric car, and at the same time cheaper to operate than the steam trains, which are usually run over the lines for which an equipment of this type is intended.—Engineering Record.

Postal Cards for Blue Prints.—The following is recommended for ferricyanide blue prints: 1. A solution of 10 grammes of ferric oxide-ammonium in 50 c. cm. of distilled water (to be preserved in a brown bottle). 2. A solution of 15 grammes of red prussiate of potash in 50 c. cm. of distilled water. Mix about equal parts of the two solutions. Apply the mixture with wadding on the back of the post cards. Ordinary post cards can be treated with these solutions.—Neueste Erfindungen und Erfahrungen.

[Concluded from SUPPLEMENT No. 1522, page 24386.]

METEOROLOGY IN THE BRITISH EMPIRE.*

By SIR JOHN ELIOT, K.C.I.E., M.A., F.R.S.

THE preceding statements have shown that variations of rainfall for prolonged periods similar in character have occurred, and may hence occur again, over the very large area including the Southern Asian peninsulas, East and South Africa, Australia, and, perhaps, the Indian Ocean. The abnormal actions or conditions giving rise to these large and prolonged variations must hence be persistent for long periods, and be effective over the whole of that extensive area, and hence cannot be inferred with certainty from the examination of the data of one small portion of the area affected—e. g., India. The variations undoubtedly accompany variations in the complete atmospheric circulation over the Indo-oceanic area, and the effective forces or actions must be such as to influence the whole movement in a similar manner in the two monsoons or seasons of inverse conditions in Southern Asia. This inference furnishes a very strong reason for the conclusion that the meteorology of the whole area similarly affected from 1892 to 1902 should be studied as a whole, and not in fragmentary detail by various weather bureaus, and as at present without any co-ordination of the results of these bureaus.

The discussion has also indicated that the southwest monsoon current is a periodic or intermittent extension of the permanent circulation of the southeast trades to the peninsulas of Southern Asia, and also that variations in the strength, volume, and direction of movement of the latter affect the extension, volume, aqueous vapor contents, and precipitation of the southwest monsoon currents in Burma, India, and Abyssinia. This fact further emphasizes the necessity for the co-ordination and systematization of the work of observation in the Indo-oceanic meteorological province and the continuous and systematic examination and discussion of observations for the whole of that area.

It is, of course, possible that it may be necessary to extend this work to a larger area than the Indo-oceanic region. For Sir Norman Lockyer and Dr. Lockyer have shown that similar pressure variations to those of Bombay occur over a large portion of the Eastern Hemisphere, and variations of opposite sign (similar to those of Cordova) over a considerable part of the Western Hemisphere.

The Indian Meteorological Department, with the sanction of the government of India, is now arranging to collect and tabulate data for the whole area between the Central Asian winter anticyclone and the permanent South Indian Ocean anticyclone, and to utilize the information for the investigation of the causes of the large and general variations of rainfall in Burma and India from year to year. This extension of its labor is recognized as necessary for the improvement of the seasonal forecasts, an important feature of the work of the department the value and importance of which are fully recognized by the government of India.

Possibly the practice of the Indian Meteorological Department in the preparation and issue of long-period or seasonal forecasts is considered to be not only unscientific, but not justified by comparison with facts. Prof. Cleveland Abbe, in his paper on "The Physical Basis of Long-range Weather Forecasts," expresses his opinion that "we are warranted in saying that during the thirteen years (1888-1900) the only real failure has been that of the prediction of the monsoon season of 1899, the year of phenomenally great drouth in that country." This opinion is probably more favorable than I should myself give, but it is the opinion of an independent meteorologist eminently qualified to give a judgment in the matter.

My own opinion with respect to weather forecasts is that there appears to be too strong a desire for absolute accuracy, possibly due to public and newspaper criticism. Certainty is not possible in weather forecasts based on imperfect information, and in which the introduction of a single unknown factor in regions beyond observation—e. g., the upper or middle atmosphere—may completely alter the course of events. Percentages of success are an inadequate measure of the utility of forecasts. To be of real value as estimates of utility, they should be calculated rather on the information required, and which might be reasonably expected, than on that actually given.

It appears to me that the striving after perfection in short-period forecasts to the exclusion of other claims is impeding the extension and progress of meteorology in other useful directions. It is absolutely essential that officials preparing or utilizing forecasts should recognize that every forecast is based on imperfect information and experience, and hence that all important forecasts should be expressed as probabilities, and, whenever desirable, an estimate of the value of each probability be given.

The government of India desires to have these seasonal forecasts, and has ordered its Meteorological Department to furnish them. The government encourages the work, provides the additional means required by the department for its proper performance, and issues the forecasts only to those who will use them as probabilities for practical guidance.

* Read before Subsection of Cosmical Physics of the British Association for the Advancement of Science.

The importance of the work of seasonal forecasting in India may be judged from the following remarks:

India is almost exclusively an agricultural country, with a population of nearly 300 millions. The material prosperity of practically the whole people is determined by the amount and distribution of the periodic rains. The variations in the amount and period of the rains are occasionally so great as to produce the most disastrous results in the staple crops over large areas. In 1899, for example, the crops failed more or less completely over an area several times the extent of England.

There is probably no country where the meteorological problems, of which these rainfall variations form one feature, are of greater interest or more practical importance. The daily weather and rainfall reports are studied during the greater part of the year with the closest attention by the officials, from the viceroy down.

The government is hence keenly interested in meteorological observation and investigation, and is most anxious to improve its meteorological service and utilize it for practical purposes, of which seasonal forecasting is one of the most important. To give two examples: A reassuring forecast at a critical period, followed by its realization, might be of the greatest value to the agricultural population of a large province, as well as to the local and imperial governments. Again, a statement or forecast the probability of which was, say, at least 10 to 1 that the rains would fail more or less completely during a season over a large area might enable the government to carry out early prudential measures for relief in the most economical and effective manner with the means at its disposal. The preparation and issue of seasonal forecasts will hence, I am confident, be in the future, as in the past, one of the most important duties of the Indian Meteorological Department.

There are several points in connection with weather forecasting in India which it is desirable should be borne in mind. The first is that weather in India is distinguished rather by the massiveness, intensity, and persistence of abnormal features than by the frequency and rapid succession of important weather changes. It is chiefly on this account that daily weather forecasts, even if they could be communicated with the necessary rapidity, are of no value to the Indian agricultural population. Also, the empirical knowledge of the significance of the important variations as factors determining or indicating future weather accumulates much more slowly than in Europe, and it is hence doubly important that in India the empirical knowledge derived from very limited experience should be, so fas as possible, regulated and controlled by theory and scientific knowledge. It should also be remembered that there are large differences between the meteorology of tropical and temperate regions, and also between the relation of crops to weather in India and England. The instincts, habits, beliefs, education of the body of the people in England and India also differ very widely. Hence the possibilities of the practical applications of meteorological science in India cannot be judged from the European standard, and may from that standpoint be unique.

The possibilities of usefulness of the work of seasonal or long-period forecasting in India are almost unlimited. To be acceptable and useful to the agricultural population of areas liable to drouth they should be fairly accurate with respect to the dates of commencement and termination of the periodic rains, their general character, and the probable occurrence of prolonged breaks likely to be injurious to the chief food crops. If the forecasts were found to be fairly trustworthy in these respects, it is quite certain that the agricultural population would value them and use them. Indications of a growing belief in the utility and value of this feature of the work of the department by the people in different parts of India are not wanting.

The government of India has sanctioned large changes in its Meteorological Department in order to enable it to carry out the extensions of work that recent experience has shown to be desirable. The department is kept in touch with scientific opinion and judgment at home through the Observatories Committee of the Royal Society. The relations to other scientific departments in India are maintained by a special committee termed the Board of Scientific Advice. The scientific staff has been largely increased. The solar physics observatory at Kodaikanal and the magnetic observatory at Bombay have been placed under the Meteorological Department with a view to the complete co-ordination of the departments of scientific investigation for which they are maintained. Observational data for the whole Indo-oceanic area are now being collected and tabulated with a view to the early publication of daily and monthly weather reports and charts of that area.

The objects of this last extension have already been indicated. It will afford the Indian meteorologists the data necessary for the investigation of the extension and intensity of the more important variations in the meteorology of the whole region, to correlate the abnormal features in the atmospheric circulation over the area, and more especially to ascertain the causes of the occasional failure of the monsoon rains in India. Finally, it will, it is hoped, enable the department to collect the information and acquire the additional experience necessary in order to render the seasonal forecasts more trustworthy and satisfactory than they have been during the past six or seven years.

The area to be dealt with (viz., the Indo-oceanic area) is partially covered by a number of independent meteorological systems, including those of Egypt, East, Central, and South Africa, Ceylon, Mauritius, the Straits Settlements, and Australia. Large areas, as, for example, Arabia, Persia, Afghanistan, Tibet, and the greater number of the islands of the Indian Ocean, are now almost completely unrepresented.

The departments controlling these systems work independently of each other, chiefly for local objects, and are in no way officially correlated or affiliated. Their methods of observation and of discussion and publication of meteorological data differ largely. It is hence difficult, if not almost impossible, to make satisfactory comparisons of the data, and trace out for the work of current meteorology the extension or field of similar variations, their relations to each other, and their probable influence on the future weather.

The work which should be carried out in order that the investigation of the meteorology of the Indo-oceanic area might be effective and as complete as possible includes the following:

(1) The extension of the field of observation by the establishment of observatories in unrepresented areas, and the systematic collection of marine meteorological data for the oceanic area.

(2) The collection and tabulation of the data necessary to give an adequate view of the larger abnormal features of the meteorology of the whole area.

(3) The direction by some authoritative body of the registration, collection, and tabulation of observations by similar methods in order to furnish strictly comparable data for discussion.

(4) The preparation of summaries of data required as preliminary to the work of discussion, and for the information of the officers controlling the work of observation in the contributory areas. The earliest publication of the data should be regarded as essential for the use of officers issuing seasonal forecasts.

(5) The scientific discussion of all the larger abnormal features in any considerable part of the area and their correlation to corresponding or compensatory variations in the remainder of the area by a central office furnished with an adequate staff.

(6) Possibly, sufficient authority on the part of the central office to initiate special observations required for the elucidation of special features for which there are no arrangements in the general work of the various systems.

The Indian Meteorological Department is making preparations to carry out a portion of this work; and will undoubtedly do the best it can single-handed with its limited means. It cannot do the work fully and as it ought to be done. It can do nothing which requires authoritative control over the remaining meteorological systems in the Indo-oceanic field. It is collecting information from those who are willing to supply it, and will utilize it for its special purposes.

It is evident the work can only be carried out fully by the co-operation of the various systems subject to limited control by a central office with acknowledged imperial or general authority behind it. The most important part of the work from the standpoint of the science of meteorology is the comparison and discussion of the whole body of observations. The constitution, position, and authority of the central office is hence of the greatest importance. It is quite certain that none of the meteorological systems directly concerned can provide such a central office. If the work is to be carried out fully and systematically it can only be arranged for in England, and by the English government assuming the general direction and control. At the present time a section of the English Meteorological Office is devoted to the study of oceanic meteorology for the information of mariners. Another section should be created for the study of imperial meteorology for the benefit of its dependencies and colonies. I have reason to believe that the government of India would contribute its share toward the cost of this extension of work.

In the preceding remarks are given the chief reasons for an important extension of work now in progress in the Indian Meteorological Department, an extension which can only be carried out imperfectly by that department, but which could be performed with most valuable scientific results by the co-ordination of the labors of the weather bureaus concerned, with a central institution or investigating office in England under government control.

Perhaps I may be permitted, from my Indian experience, to add some general remarks bearing on the methods and progress of meteorological inquiry.

In India the collection and publication of accurate current data relating to rainfall and temperature is required for the information of government in its various departments. The collection and examination of pressure and wind data by a central office with a view to the issue of storm and flood warnings is equally necessary. This work may, perhaps, be described as pertaining to descriptive or economic meteorology.

Economic meteorology, so long as it deals only with actual facts of observation, is not a science. Forecasts belong to the same department or branch of meteorology. They may be based on scientific theory and be obtained by scientific methods or the utilization of empirical knowledge. The latter method is probably sufficient for by far the greater part of short-period forecast work, but the final development of that work and the preparation of long-period forecasts require the application of exact scientific methods and knowledge. And it is, perhaps, not too much to say that the extension of the range or period of forecasts is a measure of the progress of meteorology as a science. India, by the simplicity and massiveness of its meteorological changes (and perhaps Australia and Africa), appears to be best suited for the earliest experiments in this work.

India is, however, poor, not only in material wealth and capital as compared with England, but also in the appliances and means of scientific investigation, and hence looks to England for assistance and guidance in scientific matters. Unfortunately, England lags behind, not only the United States and Germany, but even behind India, in the important field of scientific meteorological inquiry. It will suffice to give a single illustration of the anomalous and inferior position which England takes in such matters.

All meteorologists and scientific men generally are agreed that the exploration of the middle and upper atmosphere by any available means—e. g., kites, balloons, etc.—is of the utmost importance at the present stage of meteorological inquiry. The United States, France, and Germany have taken up the work vigorously. The English Meteorological Office is unable, for want of funds, to share or take any part in the work. The force of scientific and public opinion is apparently powerless to move the English government to grant an extra five hundred pounds annually for this work. The English government, on the other hand, some time ago suggested that the Indian Meteorological Department should assist. The government of India, recognizing the importance of the work, has provided the funds and sanctioned the arrangements necessary in order that its Meteorological Department may march with the most progressive nations in this investigation.

India has no body of voluntary observers or independent scientific workers and investigators. Whatever is required to be done to extend practical and theoretical meteorology can only be effected by the government department to which that work is assigned, with the sanction and at the cost of the government—which naturally considers chiefly its practical wants in relation to its limited resources. It is, from one point of view, a painful if not quite an unexpected experience to me, on my retirement, to find that the government of India is, in its attitude toward meteorological inquiry, more advanced, more liberal and far-sighted than the English government, and that England has not yet taken up seriously the work of scientific meteorological investigation. There are undoubtedly too many observations and too little serious discussion of observations. The time has arrived when investigation should go hand in hand with accurate observation, and should direct and suggest the work of observation, and also that the science directly related to meteorology should be considered concurrently with it. There are undoubtedly definite relations between certain classes of solar phenomena and phenomena of terrestrial magnetism. The probability of definite relations between solar and terrestrial meteorological phenomena is also generally admitted.

Data for the determination of these relations are being rapidly accumulated, and numerous problems connected therewith are waiting and ripe for investigation. They are too large and complex to be undertaken by present English methods, and can only be attacked by a body of trained investigators under arrangements securing the continuity of method and thought requisite for the prolonged systematic inquiry gradually leading up to their complete solution.

It would hence be desirable to enlarge the scope of the central institution I have suggested, so as to include in its field of labor the investigation of the relation between solar and terrestrial meteorology and magnetism, so far as they can be solved by the comparison of the observations of the British Empire.

The central institution would thus have large and definite fields of work and most interesting problems for investigation. It would hence contribute toward the formation of a body of scientific meteorological investigators adequate to the importance and wants of the empire, and be of the highest educational as well as scientific value.

My predecessor in this position, Dr. Shaw, the head of the English Meteorological Office, made some remarks in his address last year which deserve repetition in connection with this idea. He said: "The British Empire stands to gain more by scientific knowledge, and to lose more by unscientific knowledge, of the matter than any other country. It should from its position be the most important agency for promoting the advance of meteorological science, in the first place because it possesses such admirable varying fields of observation, and in the second place because with due encouragement British intellect may achieve as fruitful results in this as in other fields of investigation."

The establishment of the central institution as suggested above would provide a remedy for the defects pointed out by Dr. Shaw. The reorganization of the English Meteorological Office is, I believe, under consideration. Is it too much to hope that a strong expression of opinion on the part of the British Association, and the influence of the learned university at which its present meeting is held, would induce the English government to spend an additional £5,000 or £10,000 annually for the promotion of meteorological investigation and the establishment of a central imperial institution in London in connection with its Meteorological Office?

Public electric service supplied from gas engine units receiving town gas is the interesting condition at Leek, England, where, according to the Electrical Review, of London, two Stockport horizontal 100-horse-power engines are in use, coupled to 60-kilowatt dynamos. A 300-ampere-hour storage battery is employed in connection with the generating sets, and the town is supplied by two feeders, 2,820 and 1,110 feet long, respectively, and by 6,900 feet of distribution circuits.

[Continued from SUPPLEMENT No. 1521, page 24378.]

EXPERIMENTAL ELECTROCHEMISTRY.*

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EIGHTH PAPER.

Important Conditions to be Noted in Electro-chemical Operations. Caustic Soda and Chlorine from Salt. Electrolytic Production of White Lead. Electrolytic Production of Cadmium Yellow. Electrolytic Production of Mercury Vermilion. Electrolytic Production of Scheele's Green. Electrolytic Production of Berlin Blue.

VARIOUS controlling conditions must be observed in all electrochemical operations, and be recorded in connection with every piece of experimental work. There are many governing adjustments or conditions in electrolysis, without a working knowledge of which the student will be unable to meet with any notable success in carrying out a determination, or be able to obtain the same result twice in any undertaking. One of the most important factors in all electrochemical work is that of "current density," and because of its great moment and importance it will be dealt with at the opening of this chapter. Current density depends upon the ratio of electrode area to the current flow in an electrolytic cell. We may have high current density at both electrodes, or low current density at both electrodes, or else high current density at one of them and low current density at the other. Fig. 1 has been designed to make this clear. At the left in this diagram the anode is simply a thin platinum wire affording but small surface from which the electric current can leave to enter the electrolyte, whereas the cathode is a platinum sheet affording a large surface for the same current to be conducted from. At the right in the same diagram the conditions of current density are just reversed. Now the point of interest lies in the fact that adjustments of current density have an important effect upon almost all electrochemical operations, as to electrode products, as well as the chemical change which may take place throughout the entire electrolyte. Oxidation and reduction are two of the most important chemical phenomena, and yet the oxidation or reduction of an electrolyte may be brought about by an electric current, with the only difference in its application being that of current density. The following rule should be learned by all electrochemical students:

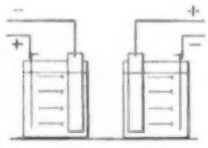

Fig. 1.—Diagram to Show Two Different Conditions of Current Density. At the Left there Exists High Current Density at the Anode and Low Current Density at the Cathode. In the Cell Depicted at the Right we have Low Current Density at the Anode and High Current Density at the Cathode.

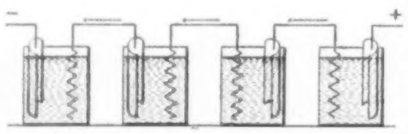

Fig. 2.—Four Cells in Series Receiving a Common Current, But Because of Dissimilar Current Density Adjustments, Electrolytes in the Several Cells will Yield Different Decomposition Products. The Electrolysis in the Two Cells at the Left will be the Same, but will Differ from the Products in the Two Cells at the Right.

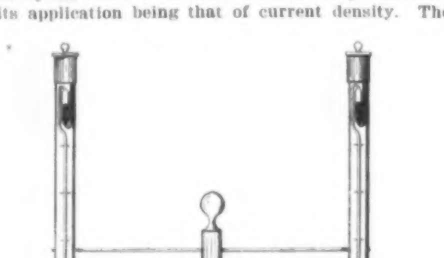

Fig. 3.—Author's Arrangement of Two Sensitive Beckmann Thermometers to Study Anode and Cathode Temperatures, when Making a Research upon an Electrolyte.

Oxidation is effected by using concentrated electrolytes and by an adjustment of low current density at the anode, as depicted in the right-hand cell in the illustration. Reduction is effected by using concentrated electrolytes and low current density at the cathode, as depicted in the left-hand cell in the illustration.

It will therefore be fully appreciated how very important it is to note and take fully into account the conditions of current density in any piece of experimental work. Fig. 2 illustrates four cells in series, the whole system, therefore, receiving a common electric current. The conditions of current density, however, are not the same, and we will obtain different results in the two cells at the right from the results in the two cells at the left. To test this we can perform the following simple experiment, using a solution of oxalic acid for the electrolytes, to which has been added a quantity of sulphuric acid. Take 60 grammes of oxalic acid to the liter of water, and add 50 grammes of sulphuric acid, and place an equal quantity in each of the four cells. A current of about half an ampere is allowed to flow for an hour, when the oxalic solutions in each cell are determined by means of permanganate of potassium. The oxidation will be found to have taken place in the two right-hand cells if the current adjustment is as shown in the diagram, and is equal for each cell. At the left there will be no notable increase, although we do not get a correspondingly great reduction. It should be stated that these current density conditions exert a strong tendency to oxidize and reduce respectively, but of course all electrolytes are not oxidizable or reducible, any more than many compounds are which go to make them up. We know that oxidation is usually accompanied by liberation of heat, and it is therefore of great moment to know both the anode and cathode temperatures in an electrochemical research. Fig. 3 illustrates the plan of the author for investigating such differential heat liberation. What are some of the other important conditions to be observed? They are many and vital, and it is deemed that a concise tabulation of them, as arranged by the author for use in the laboratory, will be perhaps a good way of presenting them. In making any kind of a research upon a solution when subjected to the action of an electric current, the conditions tabulated here should be taken account of. If a piece of experimental work is to be undertaken, a neatly-kept notebook should of course be opened, and a careful record kept of each thing observed, together with all the existing conditions. It will be necessary to make a number of repeated special runs to secure all the data as advised in the accompanying table, as there are too many conditions to be studied and recorded during any one run. For example, a special run may have to be made for differential temperatures, another for specific gravity determinations, etc. In several runs the following table may be compiled for reference. This particular table was the result of the author's work upon sulphuric acid.

Duration of run	One hour.
Compound electrolyzed	H_2SO_4.
Character of solution	No solution.
Sp. gr. before electrolysis	1.84664.
Sp. gr. after electrolysis	1.84001.
Quantity of compound taken	100 c.c.
Character of apparatus	See illustration.
Dimensions of cell	7 x 8 cm.
Source of electricity	Motor-generator.
Temperature of electrolyte	21.5 deg. C.
Temperature at anode	21.5 deg. C.
Temperature at cathode	21.5 deg. C.
Amperes flowing	4.250.
Volts indicated	16.00.
Area of anode immersed	4 sq. cm.
Area of cathode immersed	4 sq. cm.
Current density at anode	$A_{100} = 120$.
Current density at cathode	$C_{100} = 120$.
Distance between	3 cm.
Phenomenon at anode	SO_3 and O.
Phenomenon at cathode	Hydrogen.
Phenomenon between	Floating S in 3 mins.
Secondary action at anode	None at once.
Secondary action at cathode	None at once.
Secondary action between	None.
Later phenomenon at anode	SO_2 at 103.5 deg. C.
Later phenomenon at cathode	None.
Later phenomenon between	Increased S.
Material of anode	Platinum.
Material of cathode	Platinum.
Material of containing cell	Glass.
Special peculiarities	———

Many operations, of course, will not require the setting down of such elaborate data, but for all research purposes the student will do well to tabulate his facts as completely as possible. We are now in a position to produce electrolytic preparations, and a few interesting examples for laboratory practice are given here.

Caustic Soda and Chlorine from Common Salt.

This is one of the first laboratory exercises the student in experimental electrochemistry should take up in the way of preparations. The experiment is a very practical and easily carried out introduction to electrochemical manufacture. The apparatus as illustrated in the photograph in Fig. 4 is easily and quickly put together in any laboratory, and serves a most useful purpose in many cases of electrolysis where the anode gas is to be collected. The apparatus simply consists of a large beaker glass containing a good-sized porous pot, about which a cylinder of nickel wire gauze is placed to form the cathode of the cell. A cylindrical lamp chimney is next procured, and is fitted with a heavy rubber stopper, through which passes a rod of carbon to serve as the anode. There is a second small hole in this stopper, to receive a small glass tube, through which the chlorine escapes from the glass lamp chimney chamber. The rubber stopper should be given several coats of paraffin wax inside and out with a good brush dipped into a melted mass. The electrolyte consists simply of a saturated solution of common salt in water, and our lamp bank with two or three lamps in parallel in connection with an electric lighting system completes the equipment. Chlorine gas escapes copiously from the anode chamber, and a corresponding quantity of sodium hydroxide is formed in the cathode chamber. Hydrogen, of course, escapes from the nickel wire gauze when the salt breaks up in accordance with the following equation:

$$2\,NaCl + 2\,H_2O = 2\,NaOH + H_2 + Cl_2.$$

The chlorine should be led into a lead-lined box containing lead shelves and moist calcium oxide as outlined in the electrolysis of magnesium chloride, for the simultaneous production of chloride of lime, or the chlorine may be led into water to saturate it for bleaching purposes. The liquid from the cathode chamber is of course poured off after the run, and evaporated to dryness in a porcelain dish to obtain the solid caustic soda. This experiment can and should also be run quantitatively by including a copper voltameter in series with it, and noting the fall in voltage between the electrodes, in order that we may state the number of joules absorbed per gramme of sodium hydroxide produced, and per gramme of bleaching powder, etc. The porous pot partition in this apparatus plays a most important part, as it keeps the chlorine set free from acting upon the caustic soda formed to produce another compound, namely, sodium hypochlorite. As the use of porous pots is of great importance in a great many electrolytic preparations as well as in research and investigations, a little group of the various desirable shapes and sizes has been photographed, which constitutes Fig. 5. A good supply of these should be at hand in every electrochemical laboratory.

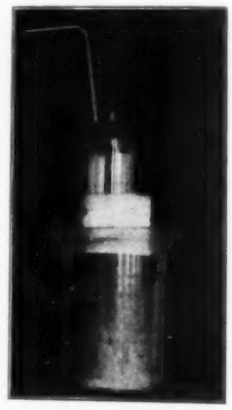

Fig. 4.—Large Beaker Arranged With Porous Pot and Glass Anode Chamber for Producing Caustic Soda and Chlorine from Common Salt.

Electrolytic Production of White Lead from Metallic Lead Electrodes.

A very beautiful electrolytic preparation is that of white lead from the metallic lead electrodes in an electrolytic cell. White lead, or technically the basic lead carbonate, has the following formula, which is sometimes called hydrate-carbonate of lead:

$$2\,PbCO_3.\,Pb\,(OH)_2.$$

For our purpose we will require either a rectangular glass jar or cell, or else a large beaker glass, and heavy sheet lead electrodes. The adjustment for current density in this preparation is the same for both electrodes, that is, they are of the same immersed area in the electrolyte. A good working current density for this experiment is 0.5 ampere for every 100 square centimeters of anode and cathode surface immersed. The expression for current density is frequently met with in abbreviated ways, which the reader of electrochemical processes will come across, and they are therefore given here in their usual manner, in order that he may become familiar with them. For example, the following expression:

$$Da = Dc = 0.5 \text{ ampere per 100 square centimeters}$$

means that the anode current density is the same as the cathode current density, and that they both equal 0.5 ampere per 100 square centimeters of immersed surface, measuring usually both sides of the two electrodes in making the calculation of area. The expression:

$$N.D._{100} = 0.5 \text{ ampere}$$

will also be met with, expressing the current flow from an electrode for every 100 square centimeters of electrode area.

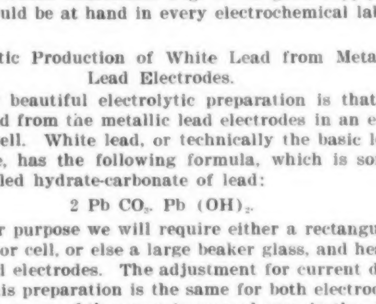

Fig. 5.—Porous Pots of Various Shapes and Sizes which should be Supplied to Every Electrochemical Laboratory.

Let us now prepare a few grammes of electrolytic white lead, and tabulate the data in such concise form that we would at any time be able to repeat the experiment with certainty or else be able to direct others to do so. The electrolyte in this case will be 12 grammes of sodium chlorate and 3 grammes of sodium carbonate dissolved in 1 liter of water. A rectangular glass cell, two sheet-lead electrodes, and our lamp bank equip

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

ent will complete the electrical requirements, and it only remains to fit up a generator for the production of carbon dioxide gas from dilute acid and fragments of marble. The electrolysis is conducted at about 20 deg. C., and a slow current of carbon dioxide gas is led into the electrolyte in contact with the cathode, the electrolyte being kept in motion by a stirrer. The white lead flows down in thick clouds from the anode to the bottom of the cell, and may be collected in a little bag of tow attached to the electrode, when it may be removed and ground with oil to make the well-known basis for oil colors. The yield of white lead in this experiment is excellent and a very pleasing lecture preparation, for the formation and falling down of the

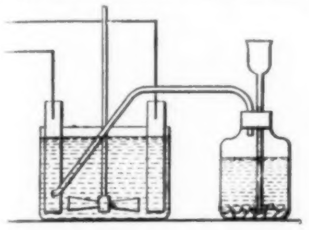
Fig. 6.—Experimental Apparatus for the Electrolytic Production of White Lead from Lead Electrodes.

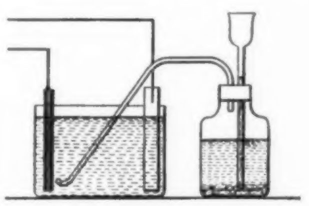
Fig. 7.—Experimental Apparatus for the Electrolytic Preparation of Cadmium Yellow from a Stick Cadmium Anode.

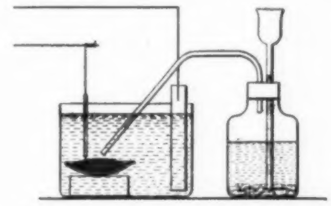
Fig. 8.—Experimental Apparatus for the Electrolytic Preparation of Mercury Vermilion from a Mercury Anode.

white lead from the solution is very beautiful and pleasing, especially when one is familiar with the unattractive old Dutch method, dependent upon the chemical action of the vapors of acetic acid, carbonic acid, and oxygen upon masses of lead in pots, which must be buried for long periods of time in horse manure, in order that fermentation may assist chemical action by an increase in temperature. Our electrolytic process may be made continuous, and has attained commercial importance in recent years. In this experiment the electrolyte contains two salts in very dilute solution. The sodium chlorate, which is present in four-fifths of the total amount, has an anion $\overline{Cl}O_3$ which forms a soluble salt with the anode lead, producing lead chlorate, which passes into solution. The sodium carbonate, whose anion $\overline{C}O_3$ forms an insoluble salt, lead carbonate, produces the precipitation. As a result of using such proportions, the insoluble salt does not deposit at once upon the anode, but is precipitated some distance from it, and does not give trouble by forming an insoluble crust on the electrode. The caustic soda produced at the cathode combines with the carbon dioxide gas which is bubbling through the solution, and regenerates sodium carbonate. Fig. 6 will make the apparatus clear. Here in the center of the cell is shown a stirrer to be operated by a small electric motor when it is desired to show the experiment in the lecture room. Below will be found tabulated the principal data in such an experimental run:

Duration of run	1 hour.
Electrolyte	12 grammes Na ClO_3, 3 grammes Na_2CO_3 in 1 liter water.
Character of apparatus	See figure.
Dimensions of cell	8 cm. × 20 cm. × 20 cm.
Source of electricity	Lighting circuit and lamp bank.
Temperature of electrolyte	20 deg. C.
Amperes flowing	0.5 ampere.
Volts indicated	60.
Area of anode immersed	100 sq. cm.
Area of cathode immersed	100 sq. cm.
Current density at anode	$N.D._{100}$ = 0.5 ampere.
Current density at cathode	$N.D._{100}$ = 0.5 ampere.
Distance between	Approximately 18 cm.
Material of anode	Soft sheet lead.
Material of cathode	Soft sheet lead.
Phenomenon at anode	White lead flowing down in streams.
Phenomenon at cathode	Bubbling of carbon dioxide gas and the formation of Na_2CO_3.

Another plan for producing a carbonate of lead can be shown with this same piece of apparatus, but with a different electrolyte. A solution of sodium nitrate is used, which when electrolyzed forms nitric acid, which attacks the lead electrode and puts it into solution as lead nitrate. The following equations show how this scheme probably works:

1. $Na\,NO_3 + H_2O = Na\,OH + HNO_3$
2. $2\,HNO_3 + Pb = Pb\,(NO_3)_2 + H_2$
3. $Pb\,(NO_3)_2 + 2\,Na\,OH = Pb\,(OH)_2 + 2\,Na\,NO_3$
4. $Pb\,(OH)_2 + HNa\,CO_3 = Pb\,CO_3 + Na\,OH + H_2O$

Instead of reactions 1 and 2 taking place as shown, the following may be the true state of affairs, since hydrogen is liberated at the cathode:

$$2\,Na\,NO_3 + 2H_2O + Pb = (2\,Na\,\overline{OH} + H_2) + Pb\,O_2 + (NO_3)_2$$

Equation 4 results from the addition to the lead hydroxide of a solution of sodium bicarbonate. Other modifications of this very beautiful method will doubtless suggest themselves to the ingenious student, apart from the interesting quantitative figures he is in a position to obtain working with such an equipment and electrical measuring instruments. Of course, for economy in operation the motor-generator should be used, as we do not require the electric current at anything like 110 volts pressure.

Having produced the white lead, which is the basis for most oil-color paint, we can next try our hands at the electrolytic production of pigments. Perhaps the easiest and most satisfactory pigment to take up first is that of cadmium yellow.

The Electrolytic Production of Cadmium Yellow.

This very brilliant and beautiful pigment may be easily produced electrolytically in a cell similar to that employed in the preparation of white lead. This cell is shown in Fig. 7, a cylindrical stick or rod of cadmium acting as anode, and a strip of platinum acting as cathode. In the place of the CO_2 generator as used in the previous preparation, a hydrogen sulphide generator is employed. For this purpose, as is well known by every chemist, we require some fragments of iron sulphide and a little dilute hydrochloric or sulphuric acid. This generator is depicted in its simplest form, and may be replaced to advantage by one of the approved "automatic" types, whereby the supply of gas controls the action of the acid upon the iron sulphide. The electrolyte in this experiment consists of a saturated solution of common salt in water, and when electrolyzed under these conditions forms cadmium chloride at the anode, and sodium hydroxide at the platinum cathode. For the production of any quantity of this pigment, both the anode and cathode should be placed in porous pots to prevent the mixing together of the respective electrode products. The cadmium chloride produced is immediately precipitated as the brilliant yellow cadmium sulphide by the stream of hydrogen sulphide gas. The following simple equation indicates the steps in the production of the pigment:

$$2\,Na\,Cl + 2\,H_2O = 2\,Na\,OH + Cl_2$$
$$2\,Cd + Cl_2 + 2\,H_2S = 2\,Cd\,S + 2\,H\,Cl$$

If the electrolyte is kept stirred by a mechanical device, the effect is very beautiful indeed. The tabulation of the data in the electrolytic preparation of cadmium yellow is given below.

Duration of run	1 hour.
Electrolyte	Saturated solution of Na Cl in water.
Character of apparatus	See figure.
Dimensions of cell	8 cm. × 20 cm. × 20 cm.
Source of electricity	Lighting circuit and lamp bank, except for economy and quantitative work. Then use motor-generator.
Temperature of electrolyte	30 deg. C.
Amperes flowing	1.00 ampere.
Volts indicated	4.5.
Area of anode immersed	50 sq. cm.
Area of cathode immersed	100 sq. cm.
Current density at anode	$N.D._{100}$ = 2 amperes.
Current density at cathode	$N.D._{100}$ = 1 ampere.
Distance between	Approximately 18 cm.
Material of anode	Rod or stick of cadmium.
Material of cathode	Strip of platinum.
Phenomenon at anode	Solution of $CdCl_2$.
Phenomenon at cathode	Liberation of hydrogen and the formation of Na OH.
Phenomenon between	The precipitation of Cd S.
Special peculiarities	Use of porous pots for the production of the pure pigment in quantity to prevent mixing of electrode products.

Note here the double current density at the anode as expressed in the abbreviated manner, as the result of using a stick of cadmium having one-half the area of the platinum strip. The next pigment is that of mercury vermilion described as follows.

The Electrolytic Production of Mercury Vermilion.

The electrolytic production of this brilliant sulphide is a little more difficult to accomplish, as the conditions must be exactly right or the scheme does not work out as smoothly as that for the preparation of the cadmium sulphide. Fig. 8 shows the arrangement of the apparatus, where a mass of mercury acting as anode is shown within a small porcelain dish, with a strip of platinum as cathode. This little dish may rest upon a block of glass, as for example a rectangular glass paper weight, for effect, if shown to a number of persons as a lecture experiment. A platinum wire runs down into the mercury, and is protected by a covering of thin rubber tubing to prevent its acting as an electrode. A hydrogen sulphide generator similar to that used in the preparation of the cadmium sulphide is employed, as shown at the right. The electrolyte consists of a solution of 8 per cent each of ammonium and sodium nitrates,

$$NH_4\,NO_3 \text{ and } Na\,NO_3$$

which electrolyze into $NH_4\,OH$ and $Na\,OH$ at the cathode, and the setting free of the two corresponding NO_3 groups at the anode, which is of mercury, and consequently the soluble mercury nitrate is formed, $Hg\,(NO_3)_2$. The hydrogen sulphide acting upon the nitrate of mercury produces the sulphide

$$Hg\,(NO_3)_2 + H_2S = Hg\,S + 2\,HNO_3$$

with the formation of two molecules of nitric acid, which, acting upon the ammonium and sodium hydroxides, reforms ammonium and sodium nitrate.

$$Na\,OH + H\,NO_3 = Na\,NO_3 + H_2O$$
$$NH_4OH + H\,NO_3 = NH_4NO_3 + H_2O$$

The following tabulation shows the important points to observe in the successful preparation of this vermilion electrolytically:

Duration of run	1 hour.
Electrolyte	8 grammes NH_4NO_3, 8 grammes $Na\,NO_3$ in 1 liter of water.
Character of apparatus	See figure.
Dimensions of cell	8 cm. × 20 cm. × 20 cm.
Source of electricity	Motor-generator.
Temperature of electrolyte	50 deg. C.
Amperes flowing	5 amperes.
Volts indicated	5.5 volts.
Area of anode immersed	200 sq. cm. approx.
Area of cathode immersed	100 sq. cm.
Current density at anode	$N.D._{100}$ = 2.5 amperes.
Current density at cathode	$N.D._{100}$ = 5 amperes.
Distance between	12 cm. approximately.
Material of anode	Metallic mercury (see illustration).
Material of cathode	Strip platinum.
Phenomenon at anode	Formation of $Hg\,(NO_3)_2$.
Phenomenon at cathode	Production of $NH_4\,OH$ and Na OH.
Special peculiarities	Arrangement of mercury in small porcelain dish.

For an effective lecture exhibit the vermilion sulphide should be agitated by means of a mechanical stirrer. Fig. 9 illustrates four electrolytic cells in series with electric motors attached to stirrers, producing a very striking apparatus for the simultaneous production of white lead and pigments. It is absolutely necessary to insulate the stirrer rods from the shafts of the motors if a common electric lighting circuit and lamp bank is employed for power for the motors and electrolyzing current. If this is not carefully done, there will, with most of the small motors on the market, be troublesome short circuits, and a failure to accomplish the electrolysis from this cause. These motors may be joined in series, and the cells should be mounted upon a board, which may be lowered by removing the support in order to withdraw the electrodes and stirrers. It is almost needless to say that this piece of apparatus will be also useful for any other operations where mechanical agitation is required for prolonged periods of time. There are other pigments which may be easily produced in the same general manner, the details of which will be left to the ingenuity of the student. For example, a beautiful green may be produced electrolytically as follows:

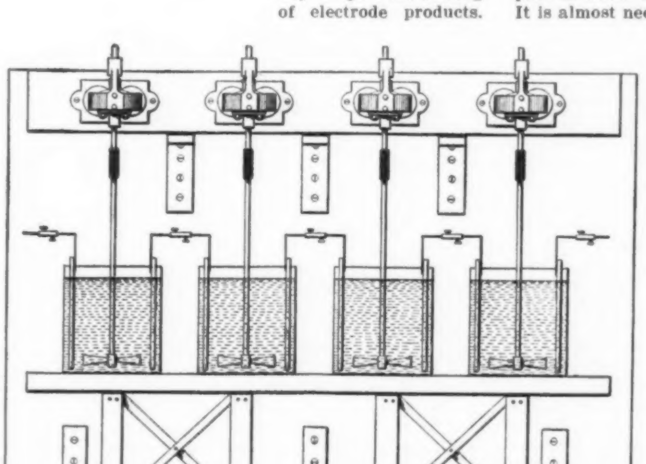
Fig. 9.—Arrangement of Electrolytic Cells with Electro-mechanical Stirrers for the Experimental Preparation of White Lead and Colored Pigments Simultaneously. This Apparatus is Designed as a Striking Lecture-room Experiment. It is Necessary to Insulate the Stirrer Rods with Hard Rubber Connections as Indicated in Black if a Common Electric Lighting Circuit is Employed for Motors and Electrolysis.

The Electrolytic Production of Scheele's Green.

For this preparation dissolve 10 grammes of sodium sulphate in 1 liter of distilled water and place in the electrolytic cell as employed for the previous compounds. The electrodes are cut from pure soft sheet copper about 5 centimeters by 25 centimeters for the size of cell we are using, and about No. 18 gage. The cell and electrolyte must be heated to a temperature of about 100 deg. C. by means of a water bath. A little bag of tow is made and filled with white arsenious oxide, which is suspended in the electrolyte. A current of about 3 amperes is necessary for a cell of this size, and it is better to employ the lighting current and the

lamp bank for the electrolyzing current. Copper sulphate and sodium hydroxide are formed, the sodium hydroxide dissolving the arsenious oxide and forming sodium arsenite. The sodium arsenite immediately precipitates the copper sulphate as the beautiful green copper arsenite, regenerating sodium sulphate. The operation may be conducted until the copper electrodes are consumed, and the arsenious oxide converted to the arsenite of copper.

The Electrolytic Production of Prussian Blue.

In the same general manner Prussian blue may be prepared in the electrolytic cell. A potassium ferrocyanide solution of 10 grammes to the liter is precipitated by means of a normal ferrous salt solution. This precipitate is stirred in water by means of our mechanical stirrer. This must be placed in a large porous pot of sufficient diameter to admit a suitable stirrer into which a platinum anode is placed. About 25 cubic centimeters of nitric acid is added to this solution in the pot and a platinum cathode is placed outside. About 5 amperes must be passed through the system for several hours, when we will obtain for our product a dark Berlin blue. A few words concerning experimental apparatus may be of service to the electrochemist. Fig. 10 illustrates a most convenient and satisfactory electrolytic stand for a great variety of purposes. The column is solid glass, which serves to mount the two electrode arms and effectually insulate them from each other. The electrode arms not only slide up and down the column and are set by means of a thumbscrew, but the electrodes may be slid in and out from the center of the column and set at any required distance. For rapid adjustment and flexibility of use these stands are unsurpassed. A half dozen or more of these stands should be a part of every electrolytic equipment. They are always ready to receive electrodes of various kinds and materials, and are quickly connected to the source of electricity by means of binding screws. Many electrochemical investigations may be begun by electrolyzing small volumes of electrolytes in beakers with these stands until data warranting the use of larger cells with separately fixed electrodes are secured.

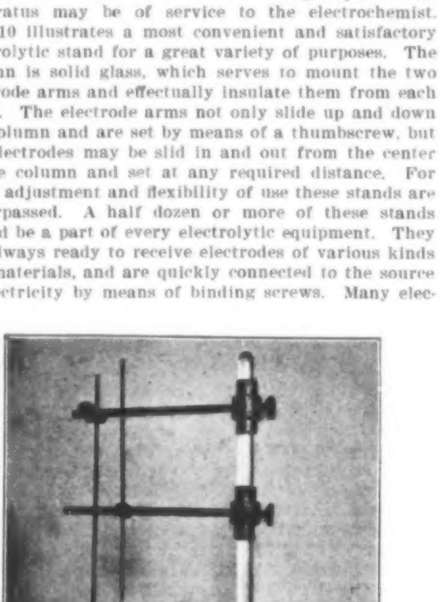

Fig. 10. Convenient Electrolytic Stand for Conducting Experimental Work. The Column is of Solid Glass, and the Electrodes are Easily Adjusted for Cells and Beakers of Various Kinds.

(To be continued.)

THE ASCENT OF WATER IN TREES.

At a recent meeting of the Royal Society a paper on "The Ascent of Water in Trees," was read by Dr. Alfred J. Ewart, Lecturer on Botany in the University of Birmingham.

Since the time when Strasburger's researches seemed to show that the ascent of water in trees was a purely physical phenomenon, attempts have been made by Dixon and Joly, as well as by Askenasy, to prove that the ascent of water is due to a tensile stress set up by transpiration in the leaves, and transmitted downward by continuous water-columns which are practically suspended from them.

Dr. Ewart finds that when the vessels are completely filled with water and are open at both ends, the flow through them takes place in accordance with Poisseuille's formula, the rate of flow being directly proportional to the pressure and inversely proportional to the viscosity of the liquid and the square of the radius of the vessel. Hence in climbing plants where a rapid rate of flow is required the vessels are large, approaching one millimeter in diameter, and in such cases the total viscosity resistance during average transpiration is equal to a head of water considerably less than the height of the stem. Under normal conditions, however, air bubbles always appear in the conducting vessels of angiospermous trees, and each bubble exerts a resistance to flow which is directly proportional to the surface tension of water against air and inversely proportional to the radius of the tube. In a tall tree the theoretical resistance due to this cause alone might amount to as much as 300 atmospheres, whereas calculations from direct experiments gave total resistances for the tallest trees of 100 atmospheres during active transpiration.

No leaf could produce or maintain an osmotic suction of this intensity, nor could the water columns in the vessels transmit it without rupture. In addition, actual observation showed that although differences do occur in the osmotic concentration of the cell-sap in the leaves at different levels, these are not sufficient to overcome the resistance to average flow in the intervening portions of the trunk. It appears, therefore, that a staircase pumping action must be exercised in the wood of a tall tree, which enables the leaves to obtain the water they require without their being forced to exercise tensions of more than one-half to two-thirds of an atmosphere. No satisfactory physical explanation of such action has yet been given; but the author points out that by appropriate surface-tension action along the length of a Jamin's chain the water could be led up from water-column to water-column, and maintained in a labile condition ready to flow in any direction where moderate suction was exercised. Various indirect estimations have been made which lend support to this view, but direct observations have not hitherto yielded satisfactory proof, so that further investigations are still needed, and are, in fact, in progress.

OLYMPIA.*

The ruins of Olympia are a delightful place in which to do nothing. Strolling among these splendid fragments in the deep grass, while the lizards are basking on the Heræon and the Byzantine church with a Philistine indifference, or perhaps a catholic breadth of sympathy, which would make a specialist shudder, one feels perhaps more than elsewhere the true atmosphere of ancient Greece. A few days amid these surroundings will teach the scholar more of old Hellenic life than the ten years which we so unprofitably spend in groping among the various readings and pedantic foot-notes of donnish editions. Here we have twelve centuries of Greek life within the compass of a morning's walk. Nero, the greatest art-collector who ever sat on a throne, is here cheek by jowl with Pindar, and Herodes Atticus, the type of the courtier-philosopher, jostles Phidias. From Pelops, the legendary winner of the first chariot-race, to Theodosius I., who prohibited the games, it seems here but a step across the Kladeos, where the frogs are croaking so loudly. Here Alcibiades, the Athenian Rosebery, gained political renown by his Olympic victory; here enemies met on neutral ground, as Boers and Britons have met on the cricket-field; here the whole Greek race, the *Ἔθνος* as the modern Greeks would say, found a bond of union in sport, just as Great and Greater Britain are federated at Lord's or Henley. And from this spot the ancient Greeks derived their method of reckoning, just as the stableman dates events from Hermit's Derby or the sporting judge calculates years by the dead-heat in the boat race. At any rate, a merrier sort of calendar than the Byzantine method which superseded it of counting time by the year of taxation.

Olympia is blest, too, above other country places in Greece by the material comforts which it provides. Here alone, in the midst of profound quiet—for there is no village, but only a few general shops and the hotels—it is possible for even the fastidious European, who must have his course dinner, to live at ease. But the warfare between the rival editors of Eatanswill was as nothing to the strife which rages between the two hotels. As far off as Pyrgos, or even Patras, the traveler is waylaid by emissaries of these opposing establishments, who extol the virtues of their own, and decry the arrangements of the other, in language which would, in England, involve an action for slander. "A place for pigs," says the Hermes of the one. "A place for Greeks, not for Europeans," rejoins the Ganymede of the other. "You will be half starved if you go to that place," impressively murmurs the first tout. "The hotel is quite unfurnished," retorts tout number two. But even when one has made one's bargain and is comfortably installed at hotel A, the determined rivalry of hotel B does not quite give one up for lost. As I was walking about among the ruins a day or so after my arrival, the landlord of the opposition house boldly accosted me and offered to take me in for the same number of *drachmai* which he imagined (quite erroneously) that I was paying in francs at my own hotel. But even this daring attempt at poaching was exceeded by a subsequent maneuver, when the rejected candidate for custom handed to one of my friends an envelope containing a *menu* of what his guests had had for lunch and a *menu* of what they were going to have for dinner, with a polite request that he would peruse the contents, and then hand the paper on to his landlord.

The excavation of Olympia has been justly described by a recent German biographer of the Emperor Frederick III. as one of that amiable prince's best memorials. To his inspiration when he was Crown Prince the great work was due, and up on the hill of Drouva were the headquarters of the excavators, one of whom lies buried near the church. What better spot than this could have been chosen for an archæologist's grave? How "Karl Kraus of Transylvania, overseer of the German excavations," died, we are not told in the German inscription, which ends with a Greek farewell, *Κραυς Χρηστέ Χαίρετε*. But here, in sight of his labors, this soldier of archæology, which hath her victories no less than war, is happier than those twin captains of classical scholarship, Ottfried Müller and Charles Lenormant, whose tombs on the hill of Kolonos at Athens are now a mark for every boy to shoot at, a slate on which every 'Arry can scribble his useless name. No student of Sophocles can visit Kolonos without a feeling akin to that with which we see an historical building sacrificed to stucco.

* Extract from "A Tour in Peloponnesos," by W. Miller, in the Westminster Review.

THE ASTRONOMY OF THE OLD TESTAMENT.

A recent book by the famous Milan astronomer, Giovanni Schiaparelli, entitled "L'Astronomia nell' Antico Testamento," is of exceptional interest. His views are in substance as follows:

The idea of the world as entertained by the Hebrew writers shows that the picture of the earth and its surroundings was not unlike that of other peoples of antiquity. The earth is regarded as a rounded plane, which divides the universe into two parts. Above is the arch of the heavens, the extreme ends of which rest upon the earth; beneath it is the deep, the abyss. The distance from the heaven to the earth can not be measured, and the same is true of the expanse of the earth. The center of the earth is found in Palestine, especially in Jerusalem (Ezekiel v. 5), a view which was entertained by Dante. The Hebrews knew of the other peoples of the earth only to the extent of about 30 degrees. Beneath the earth were to be found the great masses of the waters, the sources of the seas. These are the lower waters in contrast with the upper, which are found above the firmament. Through openings and canals the subterranean waters come to the surface of the dry land and produce rivers and springs; and they are also connected with the seas and cause these to have the same height. In this way the Hebrews explain why the seas, although rivers constantly empty into them, do not rise, and the fountains and springs do not dry up; "which explanation for its time was exceedingly thoughtful." In the depth of the abyss is Sheol, the abiding-place of the dead. Above the earth is the expanse of the firmament, firm and fixed as a mirror of metal (Job xxxviii. 18). It is a transparent vault, through which the light of the stars can be seen. On the sides above the firmament there is a second wall, which contains the receptacles of the rain, snow, and hail (Job xxxviii. 22). Beneath this space, on the same level with the earth and the sea, are the receptacles of the winds (Jeremiah x. 13; li. 16; Psalms xxxv. 7).

Above the firmament are the stars, and also the sun, which moves constantly around the earth, to rise at its accustomed place. Eclipses of the sun and moon are regarded as premonitions of divine wrath and punishments (Joel iii. 3-4; Amos viii. 9). Eclipses of the sun were exceedingly rare in Palestine, and in the times of Joel and Amos could be observed only on August 15, 831 B. C. and April 2, 824 B. C. Between 763 B. C. and the destruction of the first Temple there was no total eclipse of the sun in Palestine, so that Micah iii. 6 and Isaiah xiii. 4 can refer only to reports of earlier prophets.

Above the sun and the moon the stars are found. While the firmament is a fixed and firm vault, the starry heavens are compared with a tent curtain. As in the case of other peoples of antiquity, special groups of stars attracted particular attention, such as the big bear, Orion and the Pleiades. The totality of the stars is often called "the host of heaven." Only two planets are mentioned in the Old Testament, namely, Venus (Isaiah xiv. 12) and Saturn, which is doubtless referred to in Amos v. 26. Assyrian astrology, much to the credit of the Hebrews, was sharply antagonized by the prophets.

The Jewish division of time depended upon their astronomy. The Hebrew day began in the evening, in accordance with the universal custom of those nations that begin the month with the first appearance of the new moon. The division of the day into hours appears in a later period, and in the book of Daniel is found for the first time the word translated by the Vulgate *hora* (hour). The Hebrew year in the earliest times began in the fall; but already in 2 Kings (xi. 1) a new year in spring is mentioned. The Hebrew week of seven days is the same as that of the Babylonians, and is dependent on the phases of the moon, but not on the seven planets. The Sabbath is the only day that had a special name.

The theological and Biblical importance of these conclusions of the Milan savant are being eagerly utilized by the religious journals, especially as in general they are regarded as favoring a conservative conception of the Scriptures and their contents. In the Leipsic Kirchenzeitung (No. 35) special emphasis is laid upon the fact that not one of these conclusions in any way antagonizes the idea of revelation in the Old Testament. Mythological and superstitious elements nowhere appear in the astronomical ideas of the Old-Testament writers; indeed, Israel's ideas on these subjects are superior even to those of the gifted East Indians. The Hebrews have religiously purer conceptions of nature and its phenomena than even the educated Greeks and Romans. Here, too, this journal claims, are seen the evidences of the providential guidance and education of Israel by Jehovah.—Translations made for The Literary Digest.

Electrolytic Detectors in the Bridge Method.—W. Nernst and F. Von Lerch use Schlömilch's electrolytic detector as a null instrument in a bridge combination on account of the ease with which it is constructed and the possibility of using a telephone. Two platinum electrodes polarized with 2 volts dip into a beaker filled with dilute sulphuric acid or potash. The anode is as small as possible, and consists of a platinum wire 0.02 millimeter thick melted into a glass tube and cut off close to its end. If a rapidly oscillating current is superimposed upon this cell, a rise in the current through the polarizing circuit is noticed, and this can be easily observed by means of a telephone or galvanometer. The detector returns instantaneously to the

zero, so that one hears a crack for every spark, and is therefore enabled to follow the interruptor in the telephone. The new detector is everywhere employed with advantage where it is a question of recording feeble but rapid oscillations. For it responds to gradually decreasing oscillations in a gradually decreasing manner. In this respect it differs markedly from the coherer, which either responds fully or not at all. The mode of action of the electrolytic coherer probably consists in a piercing of transition layers formed by polarization. The apparatus works with great regularity, but it is necessary to work quickly and read the temperature accurately, as otherwise errors amounting to 2 per cent may occur.—Nernst and Von Lerch, Annalen der Physik, No. 15, 1904.

ENGINEERING NOTES.

The prize of 6,000 marks offered by the German Society of Mechanical Engineers for the best scientific treatise on locomotives, has been awarded to Prof. von Borries, who has been assisted in the work by Prof. Sommerfield, of Aix-la-Chapelle, and Herr Berner, of Berlin.

The advantages of superheating or steam jacketing as applied to steam turbines were discussed recently in the Engineering Review of London, by Mr. A. H. Gibson. He concluded that the combination of slight initial superheating and steam jacketing offers the best solution and almost ideal conditions, especially for turbines of the single-chamber Parsons type. In the case of the one-stage De Laval type high initial superheat seems to be the most suitable method, and with those of the multiple-stage—Curtis, Riedler-Stumpf, or Westinghouse-Parsons type—initial superheating to a moderately high degree, with reheating between the stages of expansion, is preferable.

A suburban close-coupled train now running on the London, Brighton, and South Coast Railway is lighted throughout with incandescent gas-burners with mantles of the inverted type, supplied by gas on the Pintsch system. This innovation appears to be to the advantage of both the railway and its passengers. The latter get a light which is much more brilliant than they are accustomed to, being of 25 candle-power against the 8 obtained with a single burner of the old fishtail type, or the 16 obtained when two burners are employed. On the other hand, the railway saves in regard to consumption of gas, for whereas one of the old burners requires 1 cubic foot an hour, the new ones take only 0.6 cubic foot each. Those who have experience of the delicacy of incandescent mantles in general may be inclined to doubt whether they will stand the jarring and jolting of a railway train without entailing such expense for renewals as will eat up the advantages arising from smaller consumption of gas; but the Pintsch Company states that the mantles employed are specially made for the purpose of a tough material which gives satisfactory durability. As a precaution against total extinction of the light should a mantle collapse, each is inclosed in a little cage of very fine wire, which would retain at least some of the fragments in position. Apart from the burners themselves, the rest of the gas-lighting equipment on the carriages remains unchanged, except that the reducing valves that control the flow of the gas from the reservoirs, where it is stored at a pressure, initially, of six or seven atmospheres, have to be regulated so that the pressure at the burners is equivalent to about 8 inches of water instead of to 1 inch, as required with a burner of the old type.—Mechanical Engineer.

The size of culverts in railway embankments has been the subject of so much discussion that there is little to be said that is new. It is important to bear in mind, however, that there is a legal as well as an engineering side to the question. The usually accepted engineering view was well expressed by the late A. M. Wellington in his "Economic Theory of Railway Location," as follows: "In a certain narrow and limited sense we may say that the natural end of a culvert, and even of many bridges, is to perish in some excessive flood. . . . When structures have been skillfully laid out to stand the ordinary contingencies of twenty or thirty years, it is about all that is either practicable or justifiable." This view often leads to the construction of culverts so small that adjoining land is flooded, and the legal aspect of culvert design thus comes to the front quite often. For example, in Uhl v. Ohio River R. R. Co., 49 S. E. Rep. 378, the Supreme Court of Appeals of West Virginia rendered the following decision last month: "Failure of a railroad company to make culverts in an embankment constructed by it for its roadbed, on lands subject to overflow, of sufficient size to permit the water behind the embankment to rise and fall as fast as the stream does, is negligent and unskillful construction, making the company liable in damages for resulting injury." Attention is drawn particularly to this decision because it contains a discussion of opinions on the subject by the courts of numerous States. The importance of the legal aspect of culvert construction is well shown by the many suits involving it which have recently been brought in different parts of the country.

Originally all important bridges, walls, and dams were built of stone, and masonry flourished as a fine art. Arches, groined and cloistered, segmental and gothic, elliptic and parabola, combined to make cathedrals and chapels beautiful, and bridges stately and strong as well as durable. Then came the era of iron and steel, and stone bridges were built no more. Steel trusses, posts and girders took the place of stone walls and granite arches. We are now going back to masonry walls and to masonry bridges, but the masonry is no longer granite; it is concrete reinforced by steel. Evidently the opening for engineering theory and engineering enterprise is most extensive. The new material is not subject to corrosion, so it will not be eaten up by rust. It is incombustible, and is not easily melted or weakened by heat, and above all it is inexpensive and easily handled. The field is a great one, and both the theory and the practice of steel and concrete combinations enter, or should enter, into the curriculum of every student of civil engineering and architecture. In the Austrian building at the recent fair in St. Louis there was a model of the centering of an arch, evidently steel-concrete, of 80 meters span (262 feet). You will remember that the beautiful and imposing Cabin John Bridge, built of granite, in Washington, D. C., the greatest stone arch in the United States, has a span of 220 feet.

The recent enormous increase in the manufacture of Portland cement is an indication of the coming demand. It has taken thousands, perhaps millions, of years in the laboratory of nature, to produce the masses of granite and the layers of marble and limestone; the engineer and the chemist working together, produce from the abundant supplies of material near at hand an artificial masonry in a few hours. Of its strength and durability the engineering laboratory and a brief experience tell us much. The verdict of a thousand years is still to be rendered, but here again the hand of promise points our way.—C. M. Woodward in a paper read at St. Louis.

ELECTRICAL NOTES.

A Dresden (Germany) suburban line is using cars, which carry 98 passengers, each car being operated by 184 cells under the seats. There are four axles each with a four-pole motor. The battery gives 430 ampere hours at 140-ampere discharge, and with a potential of 370 volts.

The French postal department has been carrying out a series of successful experiments with a new type of telautograph between the Paris Central Telephone Office and the Rouen Bourse Exchange. The apparatus is an improvement on any existing system of telautography, and has been devised by two Parisian engineers, MM. Georges Isaac and Membret. It comprises a transmitter in the shape of a desk, on which one writes a message with an ordinary pencil. This writing is reproduced on a roll of paper at the other end. Designs, drawings, music, and signatures, as well as messages prepared in Paris, were reproduced in Rouen almost instantaneously.

Electrolytic iron is dealt with by A. Skrabal in the Zeitschrift fuer Elektrochemie, and an abstract of his paper appears in the Journal of the Chemical Society. Electrolytic iron of type A is white, compact, and extremely hard. It is obtained by electrolyzing a solution of a ferrous salt with an iron anode and a small current density. Type B is grayer in color, less compact, and softer than type A. It is obtained by using a platinum anode, a large current density, and a solution of some complex ferrous salt. Between these two extremes there is a series of intermediate qualities of iron obtained by combinations of the conditions mentioned. Iron of type A (obtained by electrolyzing a solution of very pure ferrous ammonium sulphate with a platinum cathode, an anode of electrolytic iron, and an E.M.F. of about 0.4 volt) is silvery-white and sometimes distinctly crystalline. It dissolves very slowly in warm dilute sulphuric acid and rusts in moist air. Occasionally specimens are obtained which are hardly attacked by acids or haloids. Type A iron is always very hard (it usually scratches glass) and brittle, but it loses these qualities when heated to redness. When the iron is exposed to air it slowly loses hydrogen, or more rapidly when it is immersed in hot water; this loss of hydrogen does not diminish its hardness and brittleness. The author takes the view that electrolytic iron of type A is γ-iron; it is, therefore, in unstable equilibrium at the ordinary temperature. When heated, it changes into the stable α-iron, which is soft. It cannot be hardened by heating and sudden cooling, owing to the high temperature at which γ-iron changes into the β form in pure iron. The presence of large quantities of hydrogen is attributed to the greater solvent action of γ-iron, which is known to dissolve carbon much more readily than α-iron.

Mr. F. W. Steele read a paper before the Liverpool Engineering Society on the design and work of hydraulic pressing, stamping, forging, and similar machinery. In his paper the author deals with the design of heavy hydraulic presses for forging and welding processes. With these presses we are not intimately concerned as electrical engineers. The supply of these presses with water under heavy pressure can, however, be effected by means of motor-driven pumps. When this is the case the pump motor needs to be controlled from the hydraulic accumulator, and Mr. Steele describes the following arrangement as being most satisfactory. The automatic starting gear used for the motor is of the solenoid type, consisting of a main switch and a solenoid multiple-step switch. The solenoid actuating the main switch is energized as soon as the hydraulic accumulator sinks low enough for a tappet switch to close the solenoid circuit. Immediately this is done the main switch is closed and current is supplied to the motor through a number of external resistances connected in the armature circuit. At the same time current is supplied to the solenoid of the multiple-step switch, the speed of movement of which can be regulated by means of a dash-pot. As this switch moves over the contacts it closes successively by means of other solenoids subsidiary switches, which cut out the different sections of the external resistance in the main circuit. This solenoid type of control answers its purpose well, allowing the motor to be brought gradually up to full speed. The pumps then continue to supply the accumulator until it rises to such a point as to open the solenoid circuit. All the switches are then opened and the motor stops.

SCIENCE NOTES.

A clock pendulum made from invar needs no compensation, since its length is unaffected by variations of temperature. It is found that a rod of invar very slowly increases in length when kept at a constant temperature; this change extends over many years, but is not of sufficiently large magnitude to form a drawback to the use of invar in ordinary instruments of precision, although it renders this substance unsuitable for the construction of ultimate standards of length. Invar is destined to play an important part in ordinary geodetical measurements; here the small progressive expansion mentioned above is of little consequence, since the standards of length can be periodically compared with an ultimate standard; on the other hand, the increase in accuracy is very marked. M. Guillaume has designed and constructed invar standards 4 meters long of an H section with a 40-millimeter side; these are inclosed in aluminium cases, the whole of each weighing only 56 kilogrammes; the older form of standard, consisting of two scales and a rigid support, weighed 72 kilogrammes without any containing case. For field measurements invar wire standards 24 meters in length can now be used; an accuracy approaching 1 in 1,000,000 is thus attained without using any correction for temperature. The wire, which is 1.65 millimeters in diameter, can be wound on any drum exceeding 50 centimeters in diameter, so that it can be readily transported; in use, the wire is stretched by a constant load not greater than 20 kilogrammes. At present, ten men using an invar wire standard can proceed in the measurement of a base line at the rate of 5 kilometers per day; previously, fifty men using rules and microscopes could only proceed at the rate of 0.5 kilometer per day. In the future, the measurement of angles in geodesy will be controlled by the use of several long bases; while in the past the tendency was to reduce the number of base measurements as much as possible, by using numerous angular measurements. It has further been found that steel containing 45 per cent of nickel possesses the same coefficient of thermal expansion as glass, with the result that nickel-steel wires of this constitution can be used for sealing into incandescent lamps, instead of the platinum wires heretofore used. Several manufacturers of incandescent lamps are now using this alloy of nickel and iron, under the name of *platinite*; it has been estimated that by this means a ton of platinum will be saved per annum.—Technics.

We have not yet exhausted the interesting properties of nickel steel. When α or β ferrite is heated, says Technics, its elasticity diminishes; on the other hand, a great increase in elasticity accompanies the transformation from β to γ ferrite. Thus, by choosing a suitable alloy of steel, we can construct a spring of which the elasticity (Young's modulus) diminishes, remains constant, or increases with the temperature. Now the time of vibration of the balance wheel of a watch depends upon the ratio of the moment of inertia of the wheel to the Young's modulus of the hair spring; so long as this ratio remains constant the balance wheel vibrates with a constant period. A rise of temperature causes the metal of which the balance wheel is composed to expand, so increasing the moment of inertia of the balance wheel; at the same time it causes the elasticity of the spring to diminish. Both these effects tend to increase the time of vibration, but the decrease in the elasticity of the spring is the more important; a rise of temperature from 0 deg. to 30 deg. C. will cause a watch with a mono-metallic balance wheel and a steel spring to lose five minutes per day. By using a nickel-steel hair-spring of such constitution that the elasticity is constant, 90 per cent of this inaccuracy can be removed, and the cost of roughly compensating the watch can be reduced 50 per cent. Nickel steel may also be used in connection with marine chronometers, where the greatest accuracy is desirable. In the past these chronometers were compensated by the use of a compound balance wheel; the rim of the wheel was made in segments fixed only at one end, each segment consisting of an inner strip of steel and an outer strip of brass. A rise of temperature produces a greater expansion in the brass than in the steel, with the result that the free end of the segment curls round and approaches the center of the wheel, thus diminishing the moment of inertia. The compensation was so adjusted that at the two extremes of temperature to which the chronometer was likely to be subjected, the ratio of the moment of inertia of the balance wheel to the Young's modulus of the spring had equal values. In this case the chronometer keeps correct time at either of these extreme temperatures; but the celebrated English watchmaker, Dent, found, in 1833, that it gains for intermediate temperatures. The cause of this is that the decrease in the elasticity of the spring is not strictly proportional to the rise of temperature; the elasticity diminishes more and more quickly as the temperature rises. On the other hand, the decrease in the moment of inertia of the compensated balance wheel is sensibly

proportional to the rise of temperature. Thus, if the compensation is arranged so that the moment of inertia of the balance wheel bears a constant ratio to the elasticity of the spring at the two extreme temperatures, the ratio will not be constant for intermediate temperatures, but will diminish, reach a minimum, and then increase as the temperature rises. This source of error can be practically removed by using a steel spring, together with a compensated balance wheel in which a strip of nickel steel replaces the ordinary steel heretofore used. The nickel steel is chosen so that its expansion increases more and more slowly as the temperature rises, with the result that the segments of the wheel curl round more and more quickly, and decrease the moment of inertia of the wheel at a greater and greater rate, as the temperature rises. In this way the unavoidable error of a chronometer has been reduced to about one-tenth of its previous value. A chronometer, made on these principles by M. P. Ditisheim, when tested by the Kew committee in 1903, was awarded 19.7 marks out of a possible 20.

TRADE NOTES AND RECIPES.

Cement for Water Pipe.—1. Mix together 11 pounds Portland cement, 4 pounds lead white, 1 pound litharge, and make to a paste with boiled oil in which 3 per cent of its weight of colophony has been dissolved. 2. Mix torn-up wadding with its own weight of quick lime and three times its weight of boiled oil. This cement must be used as soon as made.—Hannoversches Gewerbeblatt.

Testalin, a stone protective for the production of weather-proof house-façades, consists of an alcoholic solution of oil soap and a solution of acetate of alumina. The stones or the buildings are first painted with the oil-soap solution and then with the solution of acetate of alumina. This causes solid oleate of alumina to separate, which, as far as penetration of the liquid into the stone has taken place, settles as a finely divided precipitate in the pores of the stony material.—Allgemeine Chemiker Zeitung.

Rubber oil, a rust preventive, is prepared as follows, according to a German patent: The crude oils which are obtained by the dry distillation of brown oil, peat, and other earthy substances are subjected to further distillation. Thinly rolled India rubber cut into narrow strips is saturated with four times the quantity of this oil and let stand for a week. The mass thus constituted is then submitted to the action of vulcan oil or a similar substance until a perfectly uniform clear substance has formed. This substance applied on the metal surfaces forms after slow drying a sort of film or skin which is perfectly impervious to atmospheric influences.—Die Werkstatt.

Lanolin milk is prepared as follows, according to a receipt published in the Parfumeur. Carefully rub up for some time:

Pure wool fat	50 grammes
Cocoanut oil	25 grammes
Hot water	80 grammes
Borax, powdered	8 grammes
Medicinal soap, powdered	25 grammes
Then dilute slowly with:	
Rose water, lukewarm	400 grammes
Orange flowers water, lukewarm	400 grammes
And perfume with:	
Bergamot oil	5 drops
Tincture of musk	5 drops

—Die Werkstatt.

Washing Fluid for Silver.—Various fluids may be employed to avoid the polishing entirely or for the most part. An effective fluid is made of beechwood ashes, 2 parts; Venetian soap, 0.04 part; cooking salt, 2 parts, and rain water, 8 parts. Brush the silver with this lye, using a somewhat stiff brush.

The grayish violet coating which the silverware acquires from perspiration can be readily removed with spirit of salammoniac. For the special removal of spots from silver, the following process is recommended: Lay it for four hours in soapmaker's lye, then sprinkle on finely powdered plaster of Paris, moisten the latter with vinegar so as to cause it to adhere well, dry near the fire and wipe off. Now rub the spot with dry bran. This treatment will not only cause it to disappear, but will also impart to the silver an extraordinary degree of brilliancy.—Edelmetall-Industrie.

Egg Dyes.—For the dyeing of eggs such color mixtures are preferably employed as contain along with the dye proper a fixing agent (dextrin) as well as a medium for the superficial mordanting of the eggshell. The colors will then be very brilliant.

Here are some recipes:

Color	Dyestuff	Grams	Cit. acid Gr.	Dextrin Gr.
Blue	Marine blue B. N.	3.5	35	60
Brown	Vesuvin S.	30.0	37.5	30
Green	Brilliant green O.	13.5	18.0	67.5
Orange	Orange II	9.0	18.0	75
Red	Diamond fuchsin I.	3.5	18.0	75
Pink	Eosin A.	4.5	—	90
Violet	Methyl violet 6 B.	3.6	18.0	75
Yellow	Naphthol yellow S.	13.5	36.0	67.5

About 4.5 grammes of these mixtures suffice for dyeing five eggs. The coloring matter is dissolved in 600 grammes of boiling water, while the eggs to be dyed are boiled hard, whereupon they are placed in the dye solution until they seem sufficiently colored. The dyes should be put up in wax paper.—Pharmaceutische Zeitung.

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